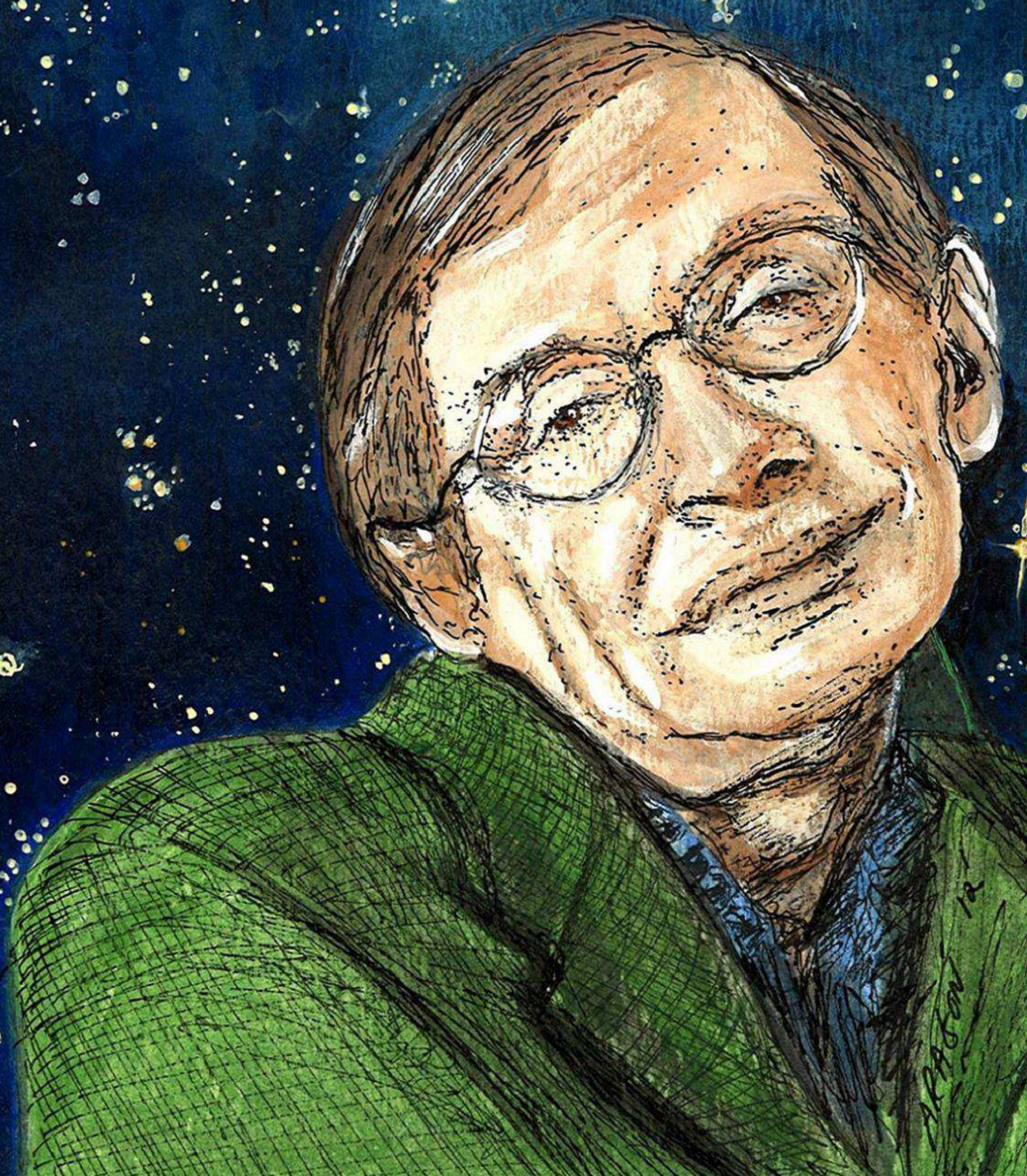


Stephen Hawking

Riddles of Time & Space





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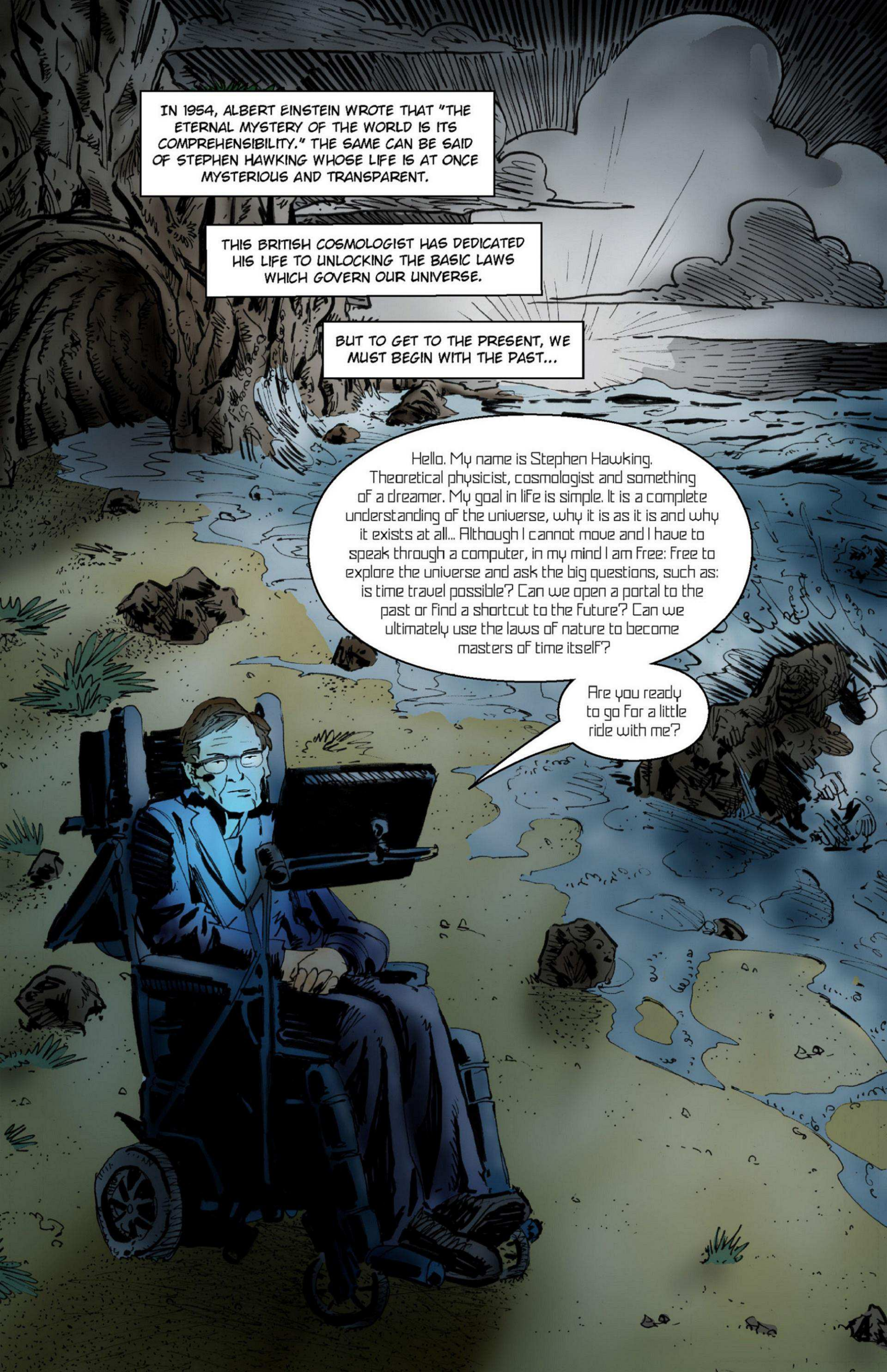
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IN 1954, ALBERT EINSTEIN WROTE THAT "THE ETERNAL MYSTERY OF THE WORLD IS ITS COMPREHENSIBILITY." THE SAME CAN BE SAID OF STEPHEN HAWKING WHOSE LIFE IS AT ONCE MYSTERIOUS AND TRANSPARENT.

THIS BRITISH COSMOLOGIST HAS DEDICATED HIS LIFE TO UNLOCKING THE BASIC LAWS WHICH GOVERN OUR UNIVERSE.

BUT TO GET TO THE PRESENT, WE MUST BEGIN WITH THE PAST...

Hello. My name is Stephen Hawking. Theoretical physicist, cosmologist and something of a dreamer. My goal in life is simple. It is a complete understanding of the universe, why it is as it is and why it exists at all... Although I cannot move and I have to speak through a computer, in my mind I am free: free to explore the universe and ask the big questions, such as: is time travel possible? Can we open a portal to the past or find a shortcut to the future? Can we ultimately use the laws of nature to become masters of time itself?

Are you ready to go for a little ride with me?

STEPHEN'S FATHER WAS DR. FRANK HAWKING, A RESEARCH BIOLOGIST. ISOBEL HAWKING, DAUGHTER OF A GLASGOW PHYSICIAN, WAS SOON TO BE HIS MOTHER.

WORLD WAR II HAD BEGUN. A GERMAN V-2 MISSILE STRUCK ONLY A FEW STREETS AWAY FROM WHERE THE HAWKING FAMILY LIVED IN LONDON.

I have noticed even people who claim everything is predestined, and that we can do nothing to change it, look before they cross the road.

STEPHEN WILLIAM HAWKING WAS BORN JANUARY 8, 1942, EXACTLY 300 YEARS AFTER THE DEATH OF GALILEO. 1942 WAS AN AUSPICIOUS YEAR -- J. ROBERT OPPENHEIMER WOULD ARRIVE AT LOS ALAMOS TO BEGIN WORKING ON THE MANHATTAN PROJECT. MEANWHILE, ENRICO FERMI AND HIS TEAM AT THE UNIVERSITY OF CHICAGO WOULD ACHIEVE THE FIRST CONTROLLED NUCLEAR CHAIN REACTION THAT SAME YEAR.

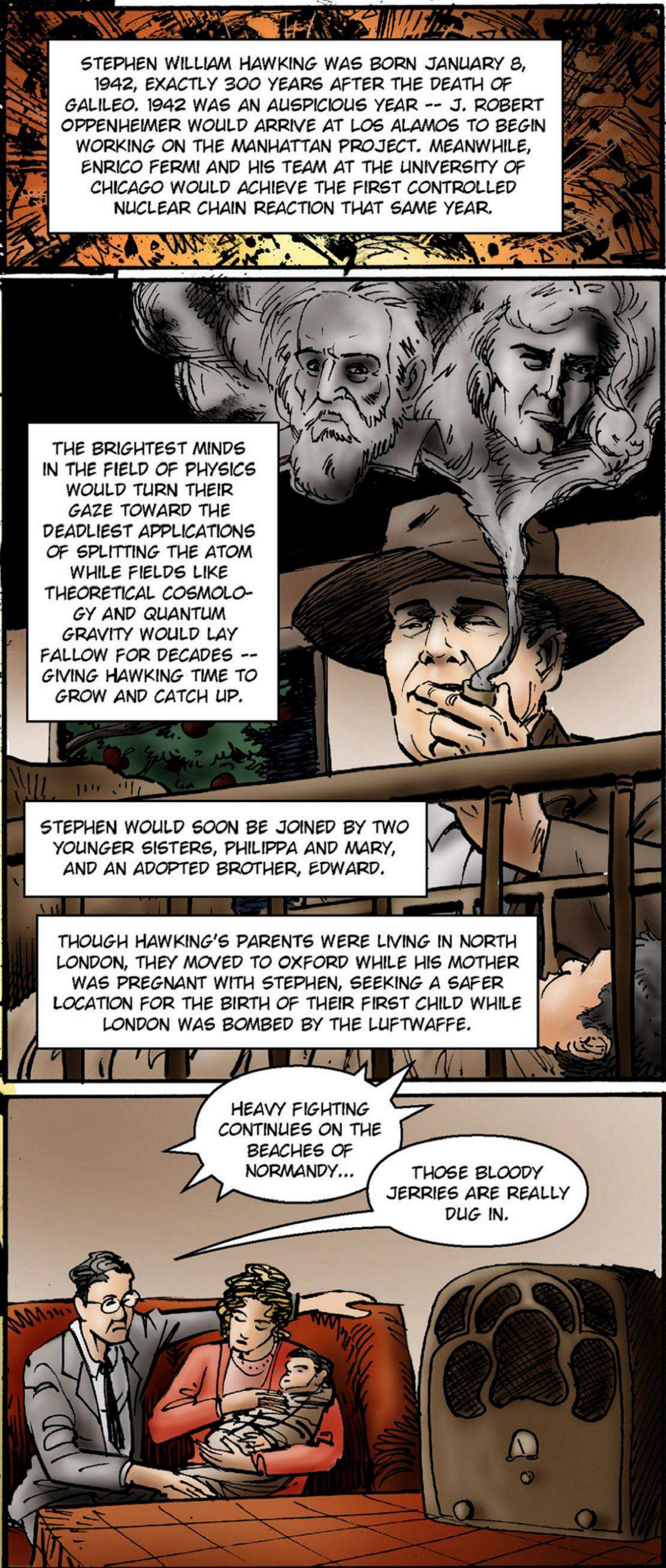
THE BRIGHTEST MINDS IN THE FIELD OF PHYSICS WOULD TURN THEIR GAZE TOWARD THE DEADLIEST APPLICATIONS OF SPLITTING THE ATOM WHILE FIELDS LIKE THEORETICAL COSMOLOGY AND QUANTUM GRAVITY WOULD LAY FALLOW FOR DECADES -- GIVING HAWKING TIME TO GROW AND CATCH UP.

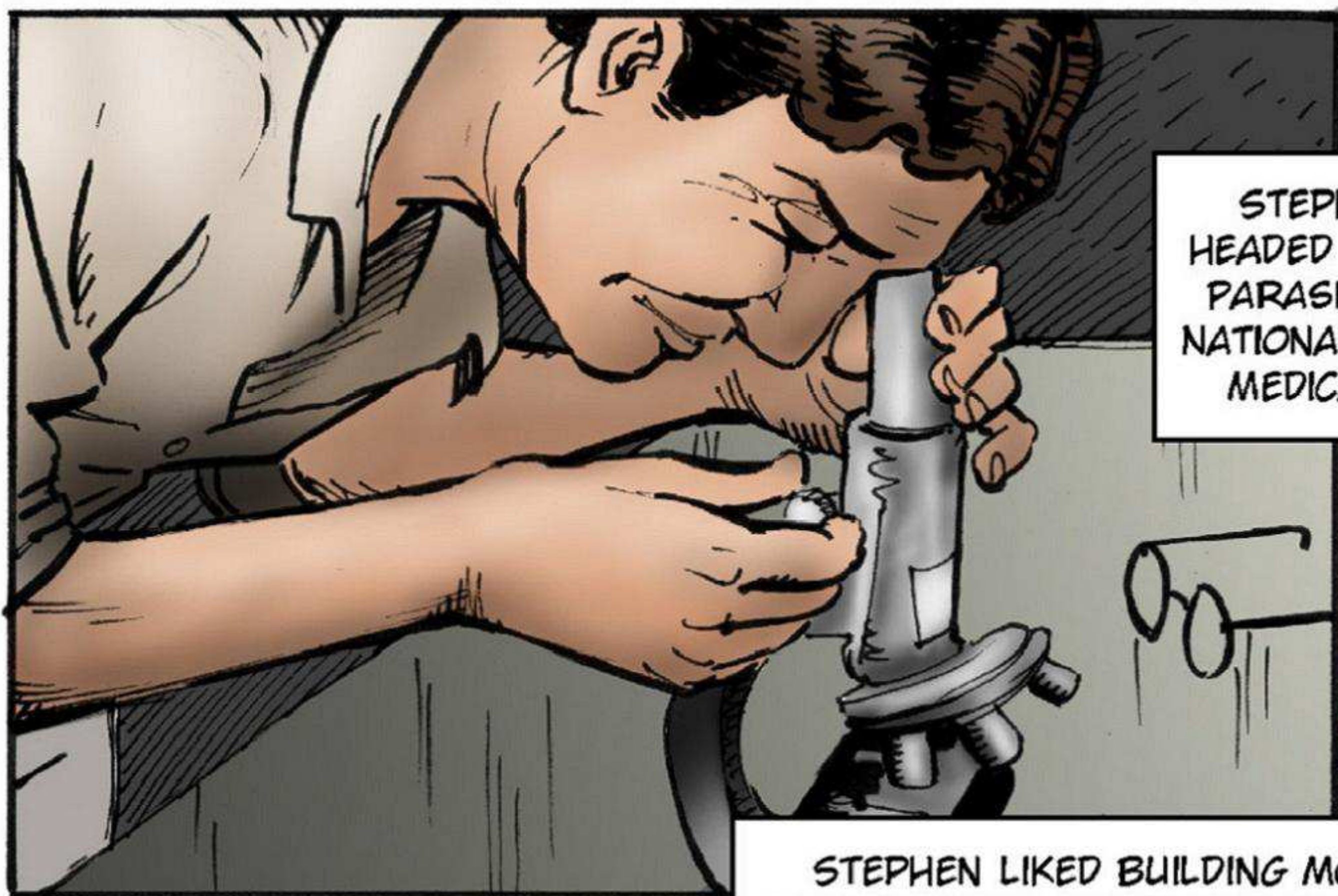
STEPHEN WOULD SOON BE JOINED BY TWO YOUNGER SISTERS, PHILIPPA AND MARY, AND AN ADOPTED BROTHER, EDWARD.

THOUGH HAWKING'S PARENTS WERE LIVING IN NORTH LONDON, THEY MOVED TO OXFORD WHILE HIS MOTHER WAS PREGNANT WITH STEPHEN, SEEKING A SAFER LOCATION FOR THE BIRTH OF THEIR FIRST CHILD WHILE LONDON WAS BOMBED BY THE LUFTWAFFE.

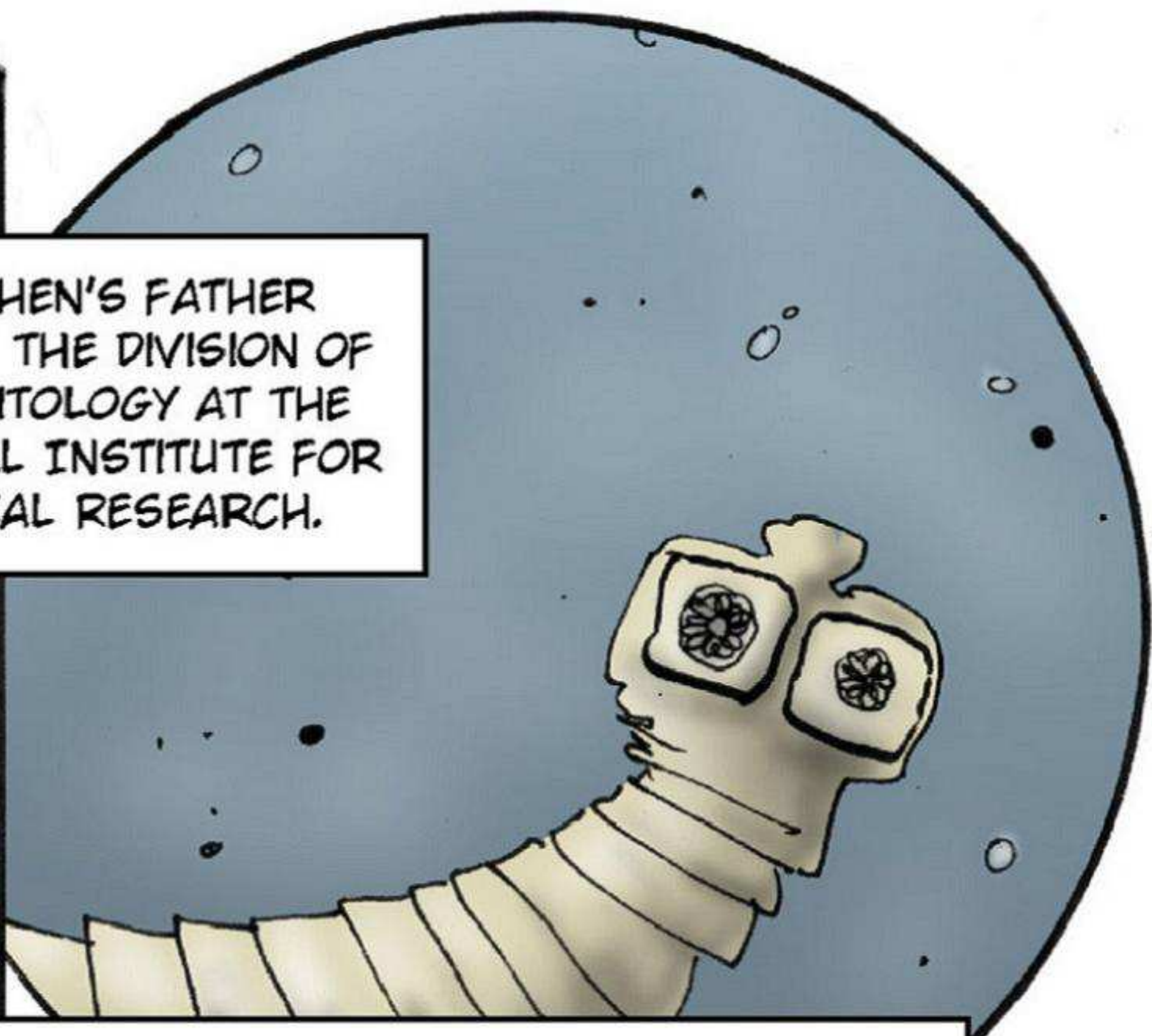
HEAVY FIGHTING CONTINUES ON THE BEACHES OF NORMANDY...

THOSE BLOODY JERRIES ARE REALLY DUG IN.

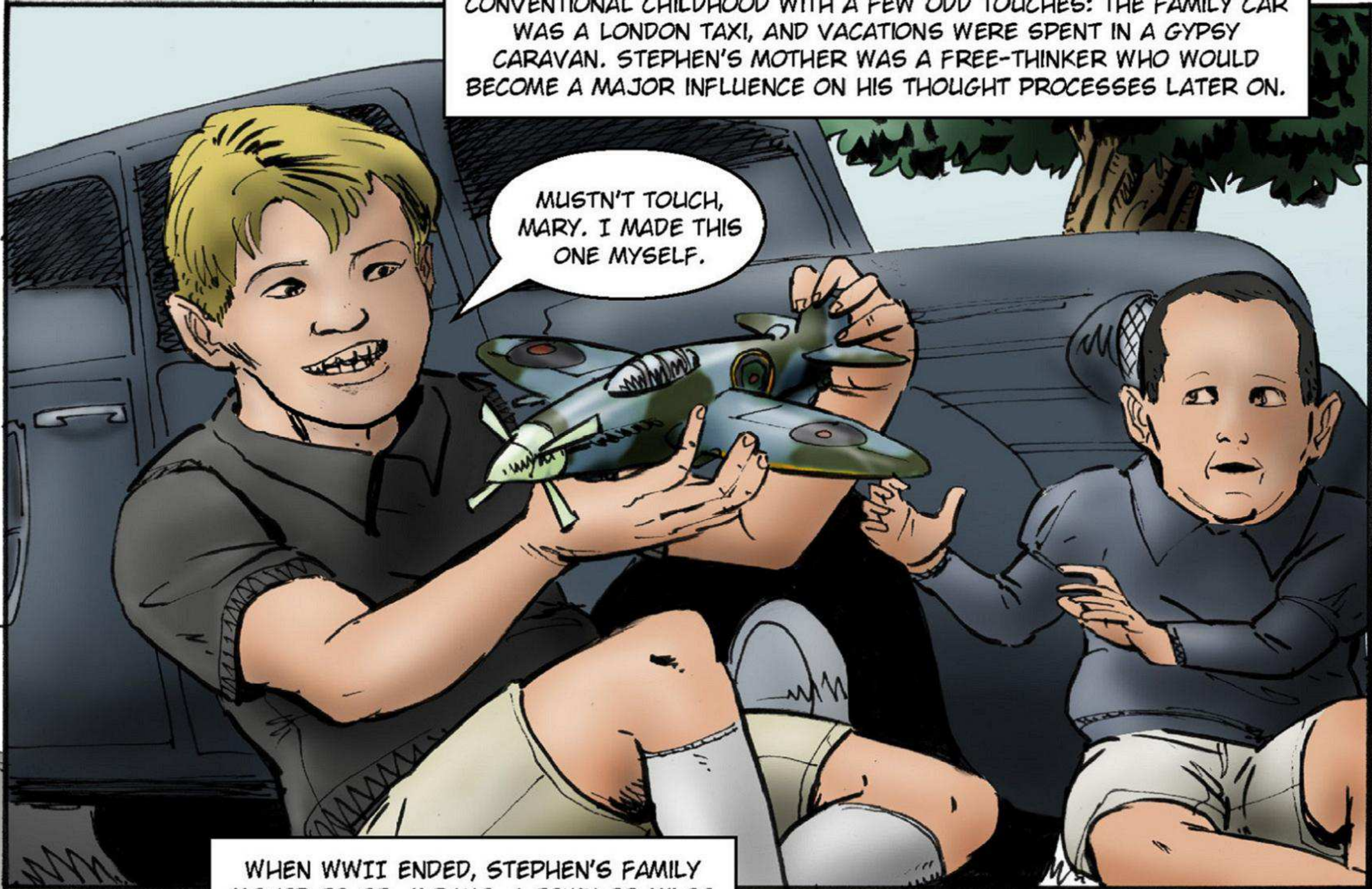




STEPHEN'S FATHER
HEADED THE DIVISION OF
PARASITOLOGY AT THE
NATIONAL INSTITUTE FOR
MEDICAL RESEARCH.



STEPHEN LIKED BUILDING MODELS AND PLAYING GAMES. IT WAS A
CONVENTIONAL CHILDHOOD WITH A FEW ODD TOUCHES: THE FAMILY CAR
WAS A LONDON TAXI, AND VACATIONS WERE SPENT IN A GYPSY
CARAVAN. STEPHEN'S MOTHER WAS A FREE-THINKER WHO WOULD
BECOME A MAJOR INFLUENCE ON HIS THOUGHT PROCESSES LATER ON.



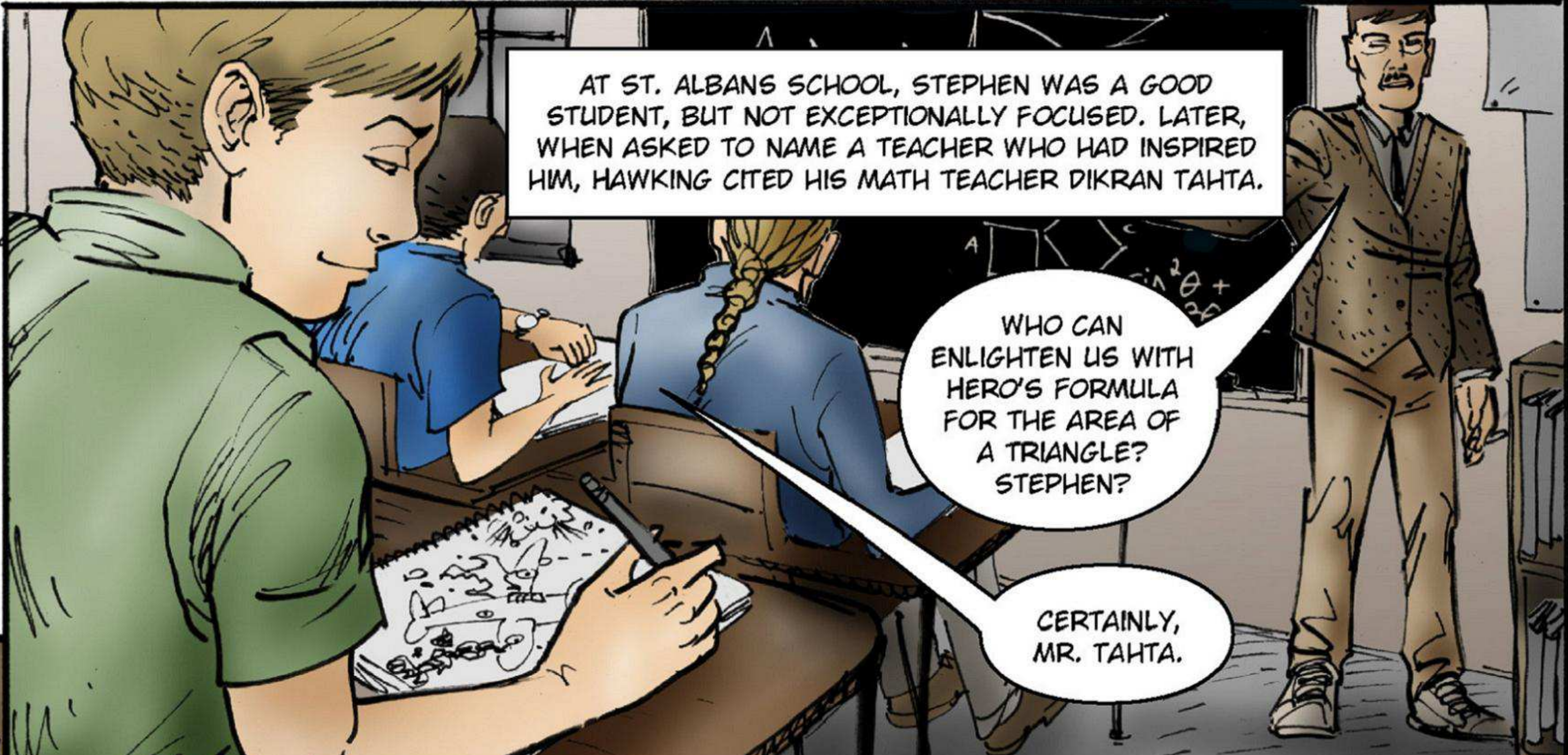
WHEN WWII ENDED, STEPHEN'S FAMILY
MOVED TO ST. ALBANS, A TOWN 22 MILES
NORTH OF LONDON. HE WAS EIGHT.



ARE WE
THERE, YET?

PAPA, WHY
IS IT TAKING
SUCH A LONG
TIME?

TIME IS
RELATIVE, BUT
YES, WE ARE
INDEED HERE.

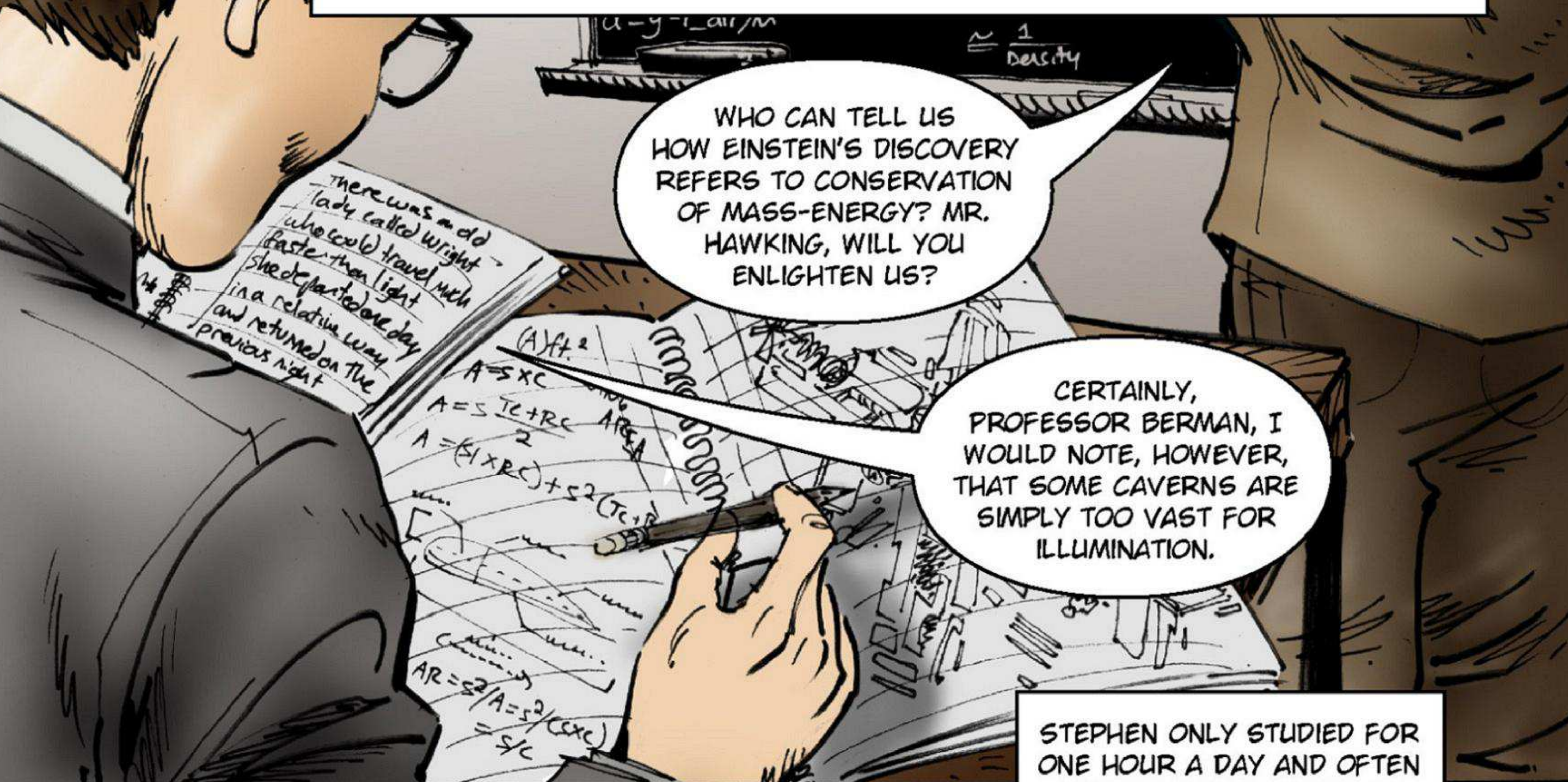


AT ST. ALBANS SCHOOL, STEPHEN WAS A GOOD STUDENT, BUT NOT EXCEPTIONALLY FOCUSED. LATER, WHEN ASKED TO NAME A TEACHER WHO HAD INSPIRED HIM, HAWKING CITED HIS MATH TEACHER DIKRAN TAHTA.

WHO CAN ENLIGHTEN US WITH HERO'S FORMULA FOR THE AREA OF A TRIANGLE? STEPHEN?

CERTAINLY, MR. TAHTA.


AFTER ST. ALBANS, HAWKING WENT ON TO UNIVERSITY COLLEGE, OXFORD; HIS FATHER'S OLD COLLEGE. HE WANTED TO STUDY MATH, ALTHOUGH HIS FATHER WOULD HAVE PREFERRED MEDICINE. HOWEVER, MATH WASN'T AVAILABLE AT UNIVERSITY COLLEGE, SO STEPHEN PURSUED PHYSICS INSTEAD. STEPHEN WAS INTERESTED IN THERMODYNAMICS, RELATIVITY, AND THE NEW SCIENCE OF QUANTUM MECHANICS.



WHO CAN TELL US HOW EINSTEIN'S DISCOVERY REFERS TO CONSERVATION OF MASS-ENERGY? MR. HAWKING, WILL YOU ENLIGHTEN US?

CERTAINLY, PROFESSOR BERMAN, I WOULD NOTE, HOWEVER, THAT SOME CAVERNS ARE SIMPLY TOO VAST FOR ILLUMINATION.

STEPHEN ONLY STUDIED FOR ONE HOUR A DAY AND OFTEN NAPPED DURING LECTURES.



HAWKING'S PHYSICS TUTOR, DR. ROBERT BERMAN, RECOUNTS THAT, "HE (HAWKING) DIDN'T HAVE VERY MANY BOOKS, AND HE DIDN'T TAKE NOTES. OF COURSE, HIS MIND WAS COMPLETELY DIFFERENT FROM ALL OF HIS CONTEMPORARIES... IT WAS ONLY NECESSARY FOR HIM TO KNOW THAT SOMETHING COULD BE DONE, AND HE COULD DO IT WITHOUT LOOKING TO SEE HOW OTHER PEOPLE DID IT."

WHILE AT OXFORD,
HAWKING JOINED
THE CREW TEAM.

SQUARE
ON THE
READY!!!

POWER 20
IN TWO, ONE!
TWO!

HAWKING WAS NOT
BURLY ENOUGH TO
BE A ROWER BUT
VERY COMPETITIVE,
EVEN RECKLESS AS
A COXSWAIN.

QUICK HANDS
AWAY!!!

HAWKING WAS VERY
POPULAR WITH HIS
TEAMMATES AND WAS
KNOWN FOR HIS RAZOR
WIT AND ACID TONGUE
WHICH HE OFTEN USED
ON HIS PROFESSORS.

BLOOD,
SWEAT AND
CHEERS, BOATIES!
DRINKS ON
ME!!!

AFTER THREE YEARS AND ADMITTEDLY NOT VERY MUCH WORK, STEPHEN WAS AWARDED A FIRST CLASS HONORS DEGREE IN NATURAL SCIENCE.

YOUR MOTHER AND I ARE VERY PROUD OF YOU.

TRUST ME, FATHER, IT WAS NOTHING.

WELL, I DON'T SUPPOSE THIS FOSSIL OF A PLACE HAS MUCH TO OFFER.

HAWKING'S POOR HABITS AND BAD ATTITUDE ALL CHANGED WHEN HE STARTED GRADUATE SCHOOL AT CAMBRIDGE IN 1962 AND SUBSEQUENTLY LEARNED THAT HE HAD ONLY A FEW YEARS TO LIVE...

SYMPTOMS OF AN UNSPECIFIED DISEASE HAD FIRST APPEARED WHILE HAWKING WAS STILL AT OXFORD. ROWING A SCULL HAD BECOME MORE DIFFICULT DESPITE HIS CONDITIONING. ALSO, STEPHEN HAD FALLEN HARD AND CLUMSILY A FEW TIMES. THE COLLEGE DOCTOR HE SAW AT OXFORD TOLD HIM NOT TO PARTY SO HARD AND TO DRINK LESS BEER.

WHAT THE BLOODY HELL??

MASTER HAWKING, ARE YOU ALRIGHT?

AHH!!!

AHHH...

ALMOST AS SOON AS HE ARRIVED AT CAMBRIDGE, HAWKING BEGAN STUDYING THEORETICAL ASTROPHYSICS AND COSMOLOGY. HE ALSO STARTED DEVELOPING SYMPTOMS OF AMYOTROPHIC LATERAL SCLEROSIS (ALS), ALSO KNOWN AS LOU GEHRIG'S DISEASE, A MOTOR NEURONE DISEASE WHICH WOULD COST HIM ALMOST ALL NEURO-MUSCULAR CONTROL.

HAWKING BEGAN STRUGGLING TO SPEAK AND STARTED TO STAGGER. HE HAD JUST TURNED 21 WHEN A SPECIALIST GAVE HIM THE BAD NEWS.

HOW COULD SOMETHING LIKE THIS HAPPEN TO ME?

I'M AFRAID YOU'VE CARRIED THIS WITH YOU SINCE BIRTH. YOU ARE ALREADY EXPERIENCING RAPID WASTING OF NERVES AND MUSCLES. NEXT WILL COME NEAR-TOTAL PARALYSIS, AND I'M AFRAID DEATH FROM RESPIRATORY FAILURE IN ABOUT 36 MONTHS...

...I RECOMMEND THAT YOU TAKE VITAMINS AND USE YOUR REMAINING TIME WISELY.

HOW DID IT GO THEN, STEPHEN?

SMASHING, JANE. I'M CLEARED FOR PRATFALLS. FANCY THE OPERA?

ALMOST AS MUCH AS I FANCY YOU.

IMMEDIATELY, HAWKING PLUNGED INTO BLACK DESPAIR AND DEPRESSION. JANE WILDE, A LANGUAGE STUDENT, WAS THERE FOR HIM THROUGHOUT. DESPITE HIS ILLNESS, JANE WAS DETERMINED TO SHOW STEPHEN THAT ANYTHING AND EVERYTHING WAS POSSIBLE. FOR A TIME, HE REMAINED UNCONVINCED.

DURING HIS FIRST TWO YEARS AT CAMBRIDGE, HAWKING WAS VERY DEPRESSED AND DID LITTLE BESIDES COURT JANE AND ATTEND WAGNERIAN OPERAS. THEY MARRIED IN 1965, TRYING TO MAKE THE MOST OF THE TIME STEPHEN HAD LEFT; HOWEVER, HIS LUCK WAS ABOUT TO CHANGE...



AFTER MOURNING THE LOSS OF HIS OWN LIFE FOR TWO YEARS, IT BECAME APPARENT TO HAWKING THAT HIS CONDITION HAD STABILIZED AND THAT HE WAS NOT ABOUT TO DIE.

FOR THE FIRST TIME IN HAWKING'S LIFE, HE FELT IT WAS TIME TO GET SERIOUS. WITH THE HELP OF HIS DOCTORAL TUTOR, DENNIS SCIAMA, HE RETURNED TO WORKING ON HIS PH.D IN THE STUDY OF THEORETICAL ASTRONOMY AND COSMOLOGY.

THE INSTANTANEOUS CREATION OF THE UNIVERSE IS LIKE A PARTY GIRL JUMPING OUT OF A CAKE -- IT'S RIDICULOUS. I CALL IT "THE BIG BANG." NOW, ON THE OTHER HAND, WITH MY OWN STEADY STATE THEORY, NEW MATTER IS CONTINUOUSLY CREATED AS THE UNIVERSE EXPANDS, SO THAT THE PERFECT COSMOLOGICAL PRINCIPLE IS ADHERED TO.

GOOD HEAVENS, HAWKING! WHAT ARE YOU DOING???

STEADY STATE IS A MODEL DEVELOPED IN 1948 BY ASTROPHYSICIST FRED HOYLE AND OTHERS AS AN ALTERNATIVE TO THE BIG BANG THEORY. STEADY STATE THEORY DICTATES THAT NEW MATTER IS CONTINUOUSLY CREATED AS THE UNIVERSE EXPANDS.

AT THE TIME HOYLE'S WAS THE PREVAILING THEORY... BUT THAT WAS BEFORE STEPHEN HAWKING -- A MERE STUDENT AT THE TIME -- TOOK A GOOD LOOK AT IT.

SO, IF THERE ARE NO QUESTIONS, I WILL NOW MOVE ON TO --

YOU'RE WRONG, SIR...

I BEG YOUR PARDON...

THE QUANTITY YOU'RE TALKING ABOUT DIVERGES.

YOU'RE SAYING I'M WRONG? HOW ON EARTH WOULD YOU KNOW?

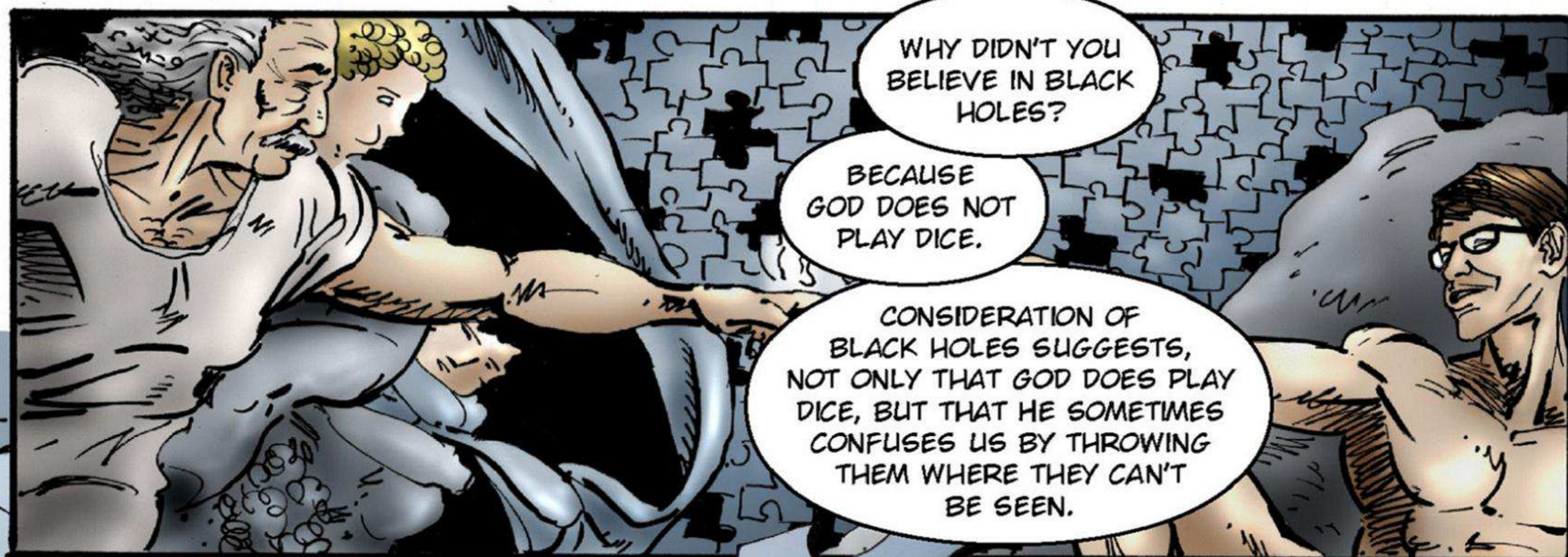
BECAUSE...

...I'VE WORKED THE QUANTITY OUT IN MY HEAD.

INDEED, HAWKING PROVED THAT HOYLE'S CONCLUSIONS AND RESULTING THEORY WERE WRONG BECAUSE THE QUANTITY THEY WERE BASED ON WAS FLAWED.

AFTER GAINING HIS PH.D. HAWKING BECAME FIRST A RESEARCH FELLOW AND LATER ON A PROFESSORIAL FELLOW AT GONVILLE AND CAIUS COLLEGE.

ON THAT DAY, STEPHEN HAWKING, COSMOLOGIST, WAS BORN.



IN 1965, PHYSICISTS WORKING AT BELL LABS IN NEW JERSEY DISCOVERED COSMIC MICROWAVE BACKGROUND RADIATION, DIRECT EVIDENCE THAT THE UNIVERSE BEGAN WITH THE **BIG BANG**. HOWEVER, TANTALIZING QUESTIONS REMAINED: WAS THE BIG BANG A **SINGULARITY** -- A PLACE IN EITHER SPACE OR TIME AT WHICH SOME QUANTITY BECOMES INFINITE -- OR WAS IT A DENSE HOT BALL OF ENERGY--INCREDIBLY POWERFUL AND DIFFICULT TO FATHOM, BUT STILL DESCRIBABLE BY THE KNOWN LAWS OF PHYSICS?

BLACK HOLES ARE THE FINAL STAGE OF A COLLAPSED STAR -- STAR CRUSHING REGIONS IN SPACE WHERE THE GRAVITATIONAL FIELD HAS INFINITE STRENGTH AND EVEN LIGHT CANNOT ESCAPE.

WITH THESE QUESTIONS IN MIND, IN THE LATE 1960S AND EARLY 1970S, HAWKING AND HIS CAMBRIDGE FRIEND AND COLLEAGUE, SIR ROGER PENROSE, APPLIED A NEW, COMPLEX MATHEMATICAL MODEL THEY HAD CREATED FROM EINSTEIN'S THEORY OF GENERAL RELATIVITY TO PROVE THE FIRST OF MANY SINGULARITY THEOREMS, THE POINTS WHERE SPACE, TIME, AND THE VERY LAWS OF PHYSICS FALL APART.

SUCH THEOREMS PROVIDE A SET OF SUFFICIENT CONDITIONS FOR THE EXISTENCE OF A GRAVITATIONAL SINGULARITY IN SPACE-TIME.

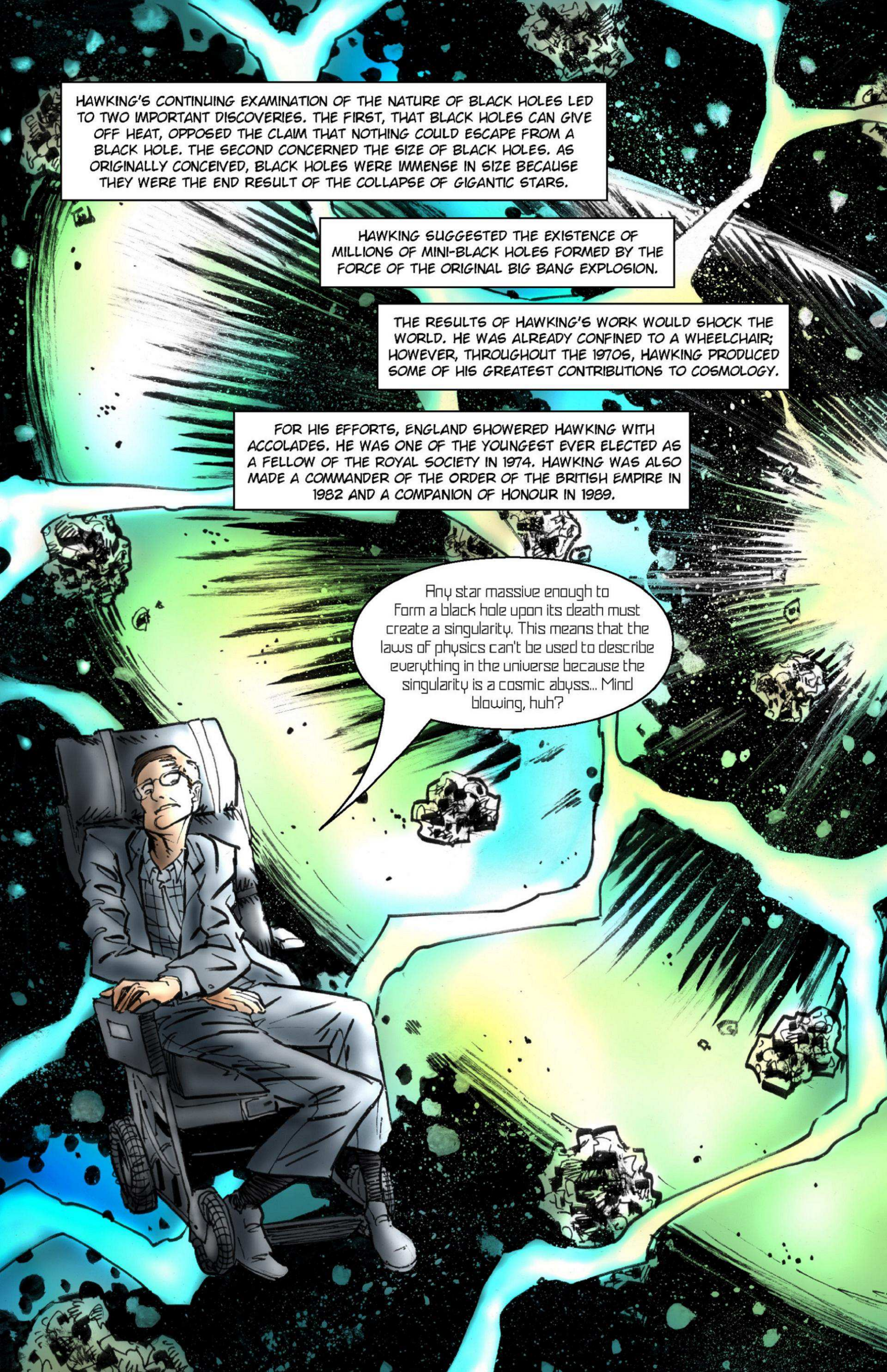
THE WORK OF HAWKING AND PENROSE SHOWED THAT, FAR FROM BEING MATHEMATICAL CURIOSITIES THAT APPEAR ONLY IN SPECIAL CASES, SINGULARITIES ARE A RATHER COMMON FEATURE OF GENERAL RELATIVITY.

HAWKING DEMONSTRATED THAT OUR UNIVERSE HAD ITS ORIGINS IN A SINGULARITY WITH ALL OF THE MATTER IN THE UNIVERSE CONCENTRATED IN A SINGLE POINT, MAKING A VERY SMALL BUT TREMENDOUSLY DENSE BODY.

TEN TO TWENTY BILLION YEARS AGO, THAT BODY EXPLODED IN A BIG BANG THAT INITIATED TIME AND THE UNIVERSE.

HAWKING'S RESEARCH LED HIM TO STUDY THE CHARACTERISTICS OF A WELL-KNOWN SINGULARITY: THE BLACK HOLE. IN 1973, HAWKING SHOWED THAT BLACK HOLES WERE NOT COMPLETELY BLACK BUT COULD LEAK RADIATION AND EVENTUALLY EXPLODE AND DISAPPEAR, A FINDING THAT IS STILL REVERBERATING THROUGH PHYSICS AND COSMOLOGY.

A BLACK HOLE'S EDGES, CALLED THE **EVENT HORIZON**, CAN BE DETECTED. HAWKING PROVED THAT THE SURFACE AREA OF THE EVENT HORIZON COULD ONLY INCREASE, NOT DECREASE, AND THAT WHEN TWO BLACK HOLES MERGED THE SURFACE AREA OF THE NEW HOLE WAS LARGER THAN THE SUM OF THE TWO ORIGINAL.



HAWKING'S CONTINUING EXAMINATION OF THE NATURE OF BLACK HOLES LED TO TWO IMPORTANT DISCOVERIES. THE FIRST, THAT BLACK HOLES CAN GIVE OFF HEAT, OPPOSED THE CLAIM THAT NOTHING COULD ESCAPE FROM A BLACK HOLE. THE SECOND CONCERNED THE SIZE OF BLACK HOLES. AS ORIGINALLY CONCEIVED, BLACK HOLES WERE IMMENSE IN SIZE BECAUSE THEY WERE THE END RESULT OF THE COLLAPSE OF GIGANTIC STARS.

HAWKING SUGGESTED THE EXISTENCE OF MILLIONS OF MINI-BLACK HOLES FORMED BY THE FORCE OF THE ORIGINAL BIG BANG EXPLOSION.

THE RESULTS OF HAWKING'S WORK WOULD SHOCK THE WORLD. HE WAS ALREADY CONFINED TO A WHEELCHAIR; HOWEVER, THROUGHOUT THE 1970S, HAWKING PRODUCED SOME OF HIS GREATEST CONTRIBUTIONS TO COSMOLOGY.

FOR HIS EFFORTS, ENGLAND SHOWERED HAWKING WITH ACCOLADES. HE WAS ONE OF THE YOUNGEST EVER ELECTED AS A FELLOW OF THE ROYAL SOCIETY IN 1974. HAWKING WAS ALSO MADE A COMMANDER OF THE ORDER OF THE BRITISH EMPIRE IN 1982 AND A COMPANION OF HONOUR IN 1989.

Any star massive enough to form a black hole upon its death must create a singularity. This means that the laws of physics can't be used to describe everything in the universe because the singularity is a cosmic abyss... Mind blowing, huh?

BUT BY 1974, HAWKING WAS UNABLE TO FEED HIMSELF OR GET OUT OF BED. HIS SPEECH BECAME SO SLURRED THAT HE COULD BE UNDERSTOOD ONLY BY PEOPLE WHO KNEW HIM WELL. HE WAS UNABLE TO USE EVEN THE BASIC TOOLS OF HIS TRADE, NAMELY SLIDE RULERS, PENCILS AND CHALK.

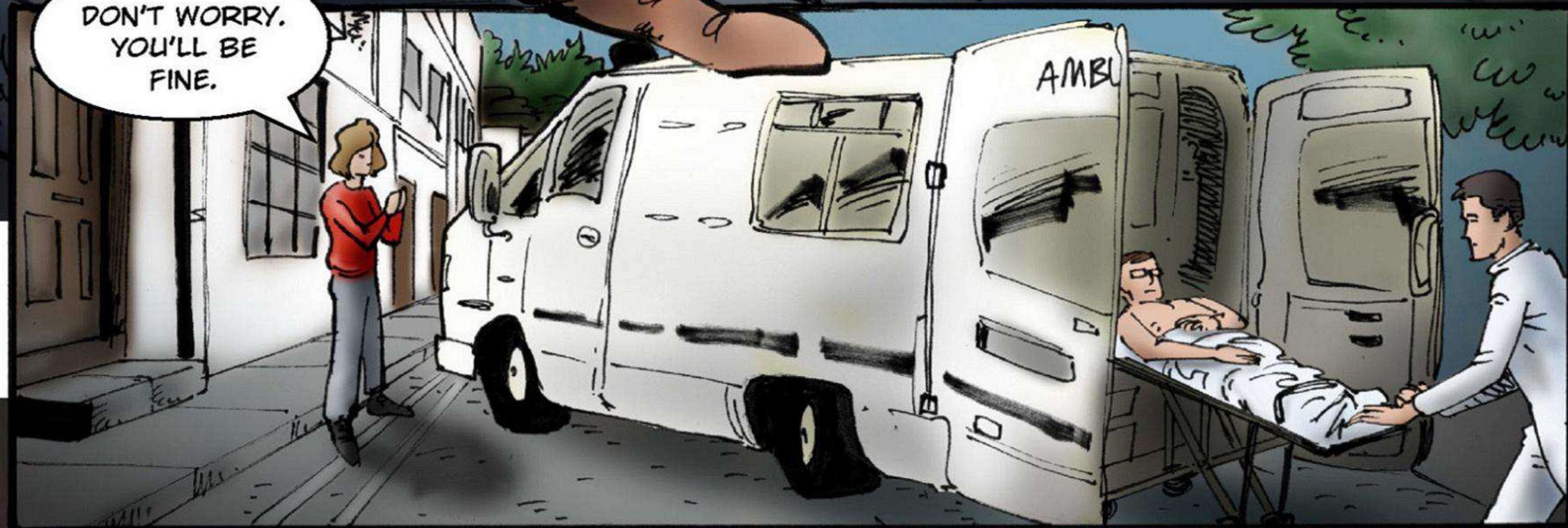
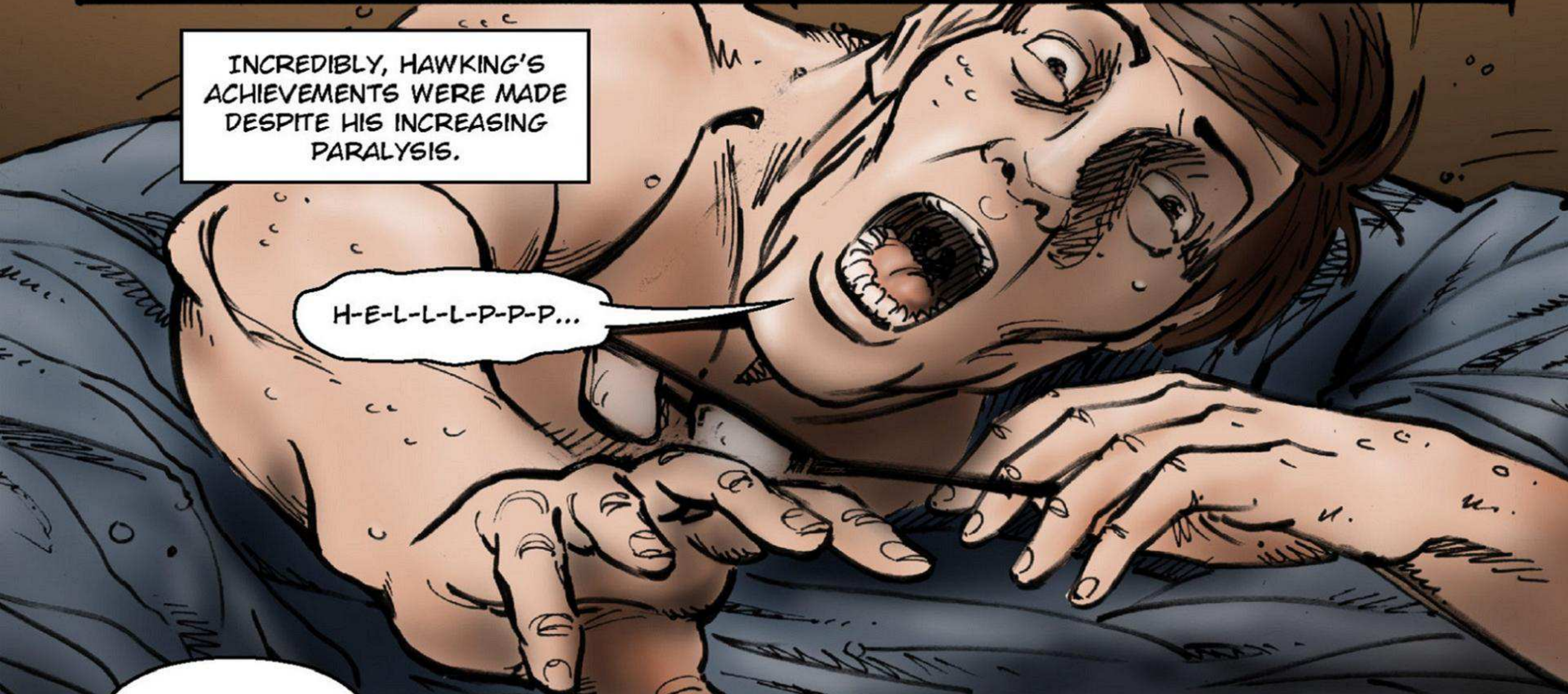
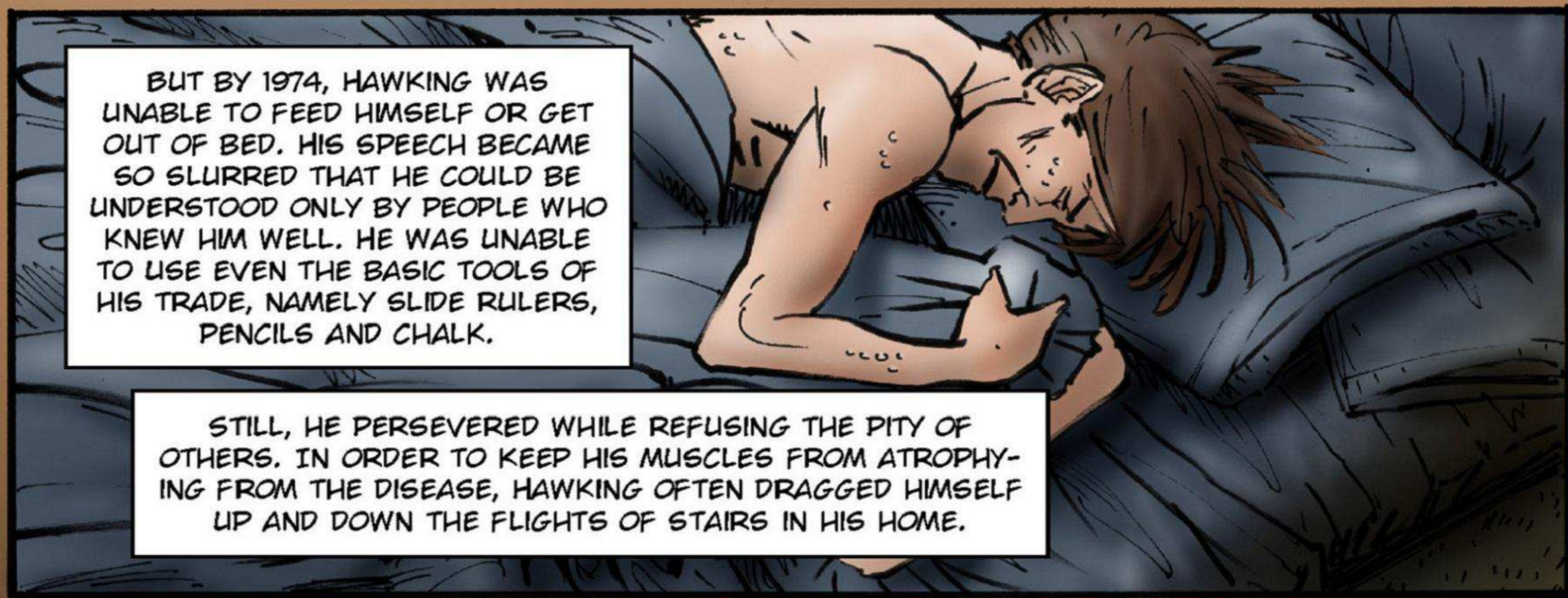
STILL, HE PERSEVERED WHILE REFUSING THE PITY OF OTHERS. IN ORDER TO KEEP HIS MUSCLES FROM ATROPHYING FROM THE DISEASE, HAWKING OFTEN DRAGGED HIMSELF UP AND DOWN THE FLIGHTS OF STAIRS IN HIS HOME.

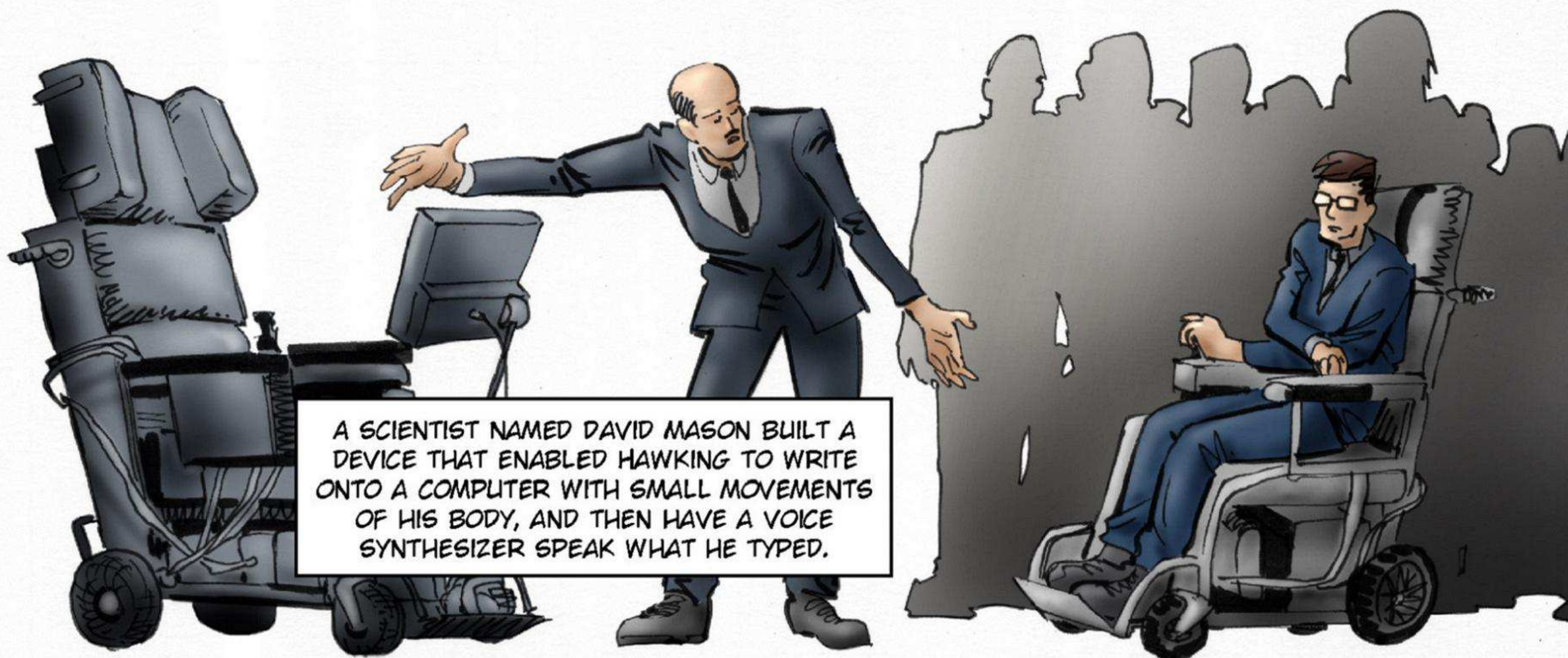
INCREDIBLY, HAWKING'S ACHIEVEMENTS WERE MADE DESPITE HIS INCREASING PARALYSIS.

H-E-L-L-L-P-P-P...

DON'T WORRY.
YOU'LL BE
FINE.

IN 1985, HE CAUGHT PNEUMONIA AND HAD TO HAVE A TRACHEOTOMY, WHICH RENDERED HIM SPEECHLESS, UNABLE TO SPEAK AT ALL.



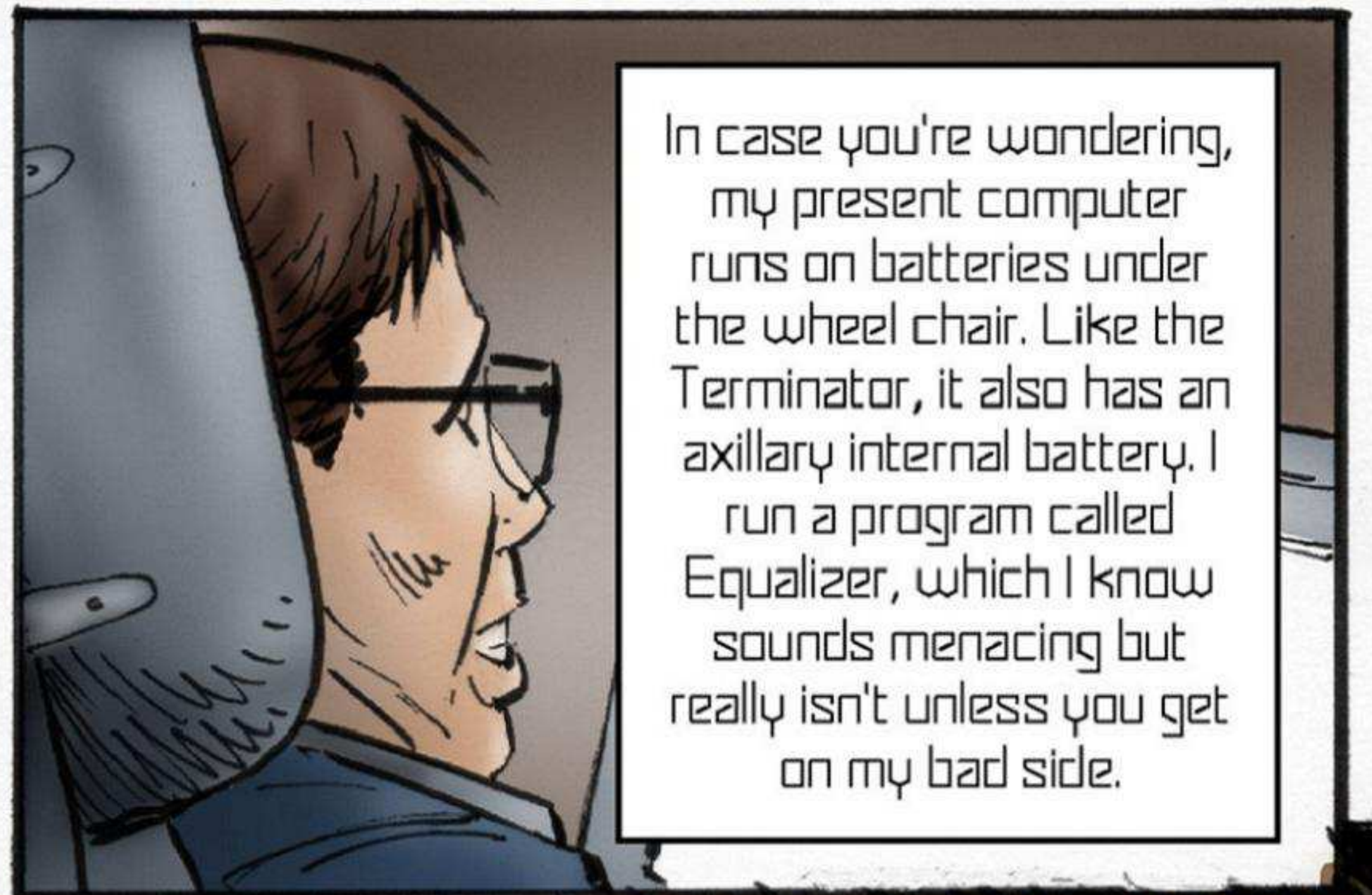


A SCIENTIST NAMED DAVID MASON BUILT A DEVICE THAT ENABLED HAWKING TO WRITE ONTO A COMPUTER WITH SMALL MOVEMENTS OF HIS BODY, AND THEN HAVE A VOICE SYNTHESIZER SPEAK WHAT HE TYPED.

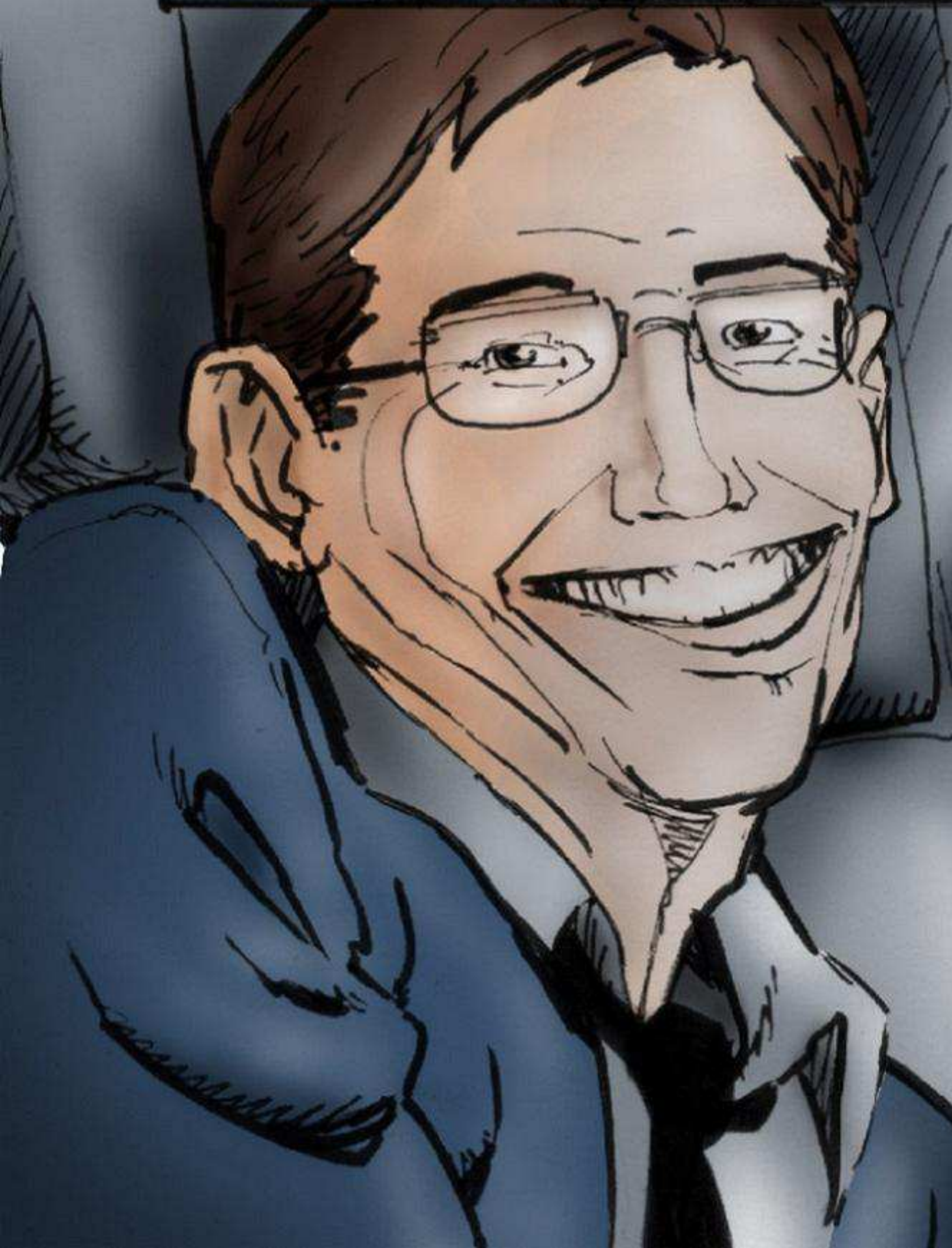


Brave-new-world.

But-why-do-I-sound-like-a-bloody... Yank?



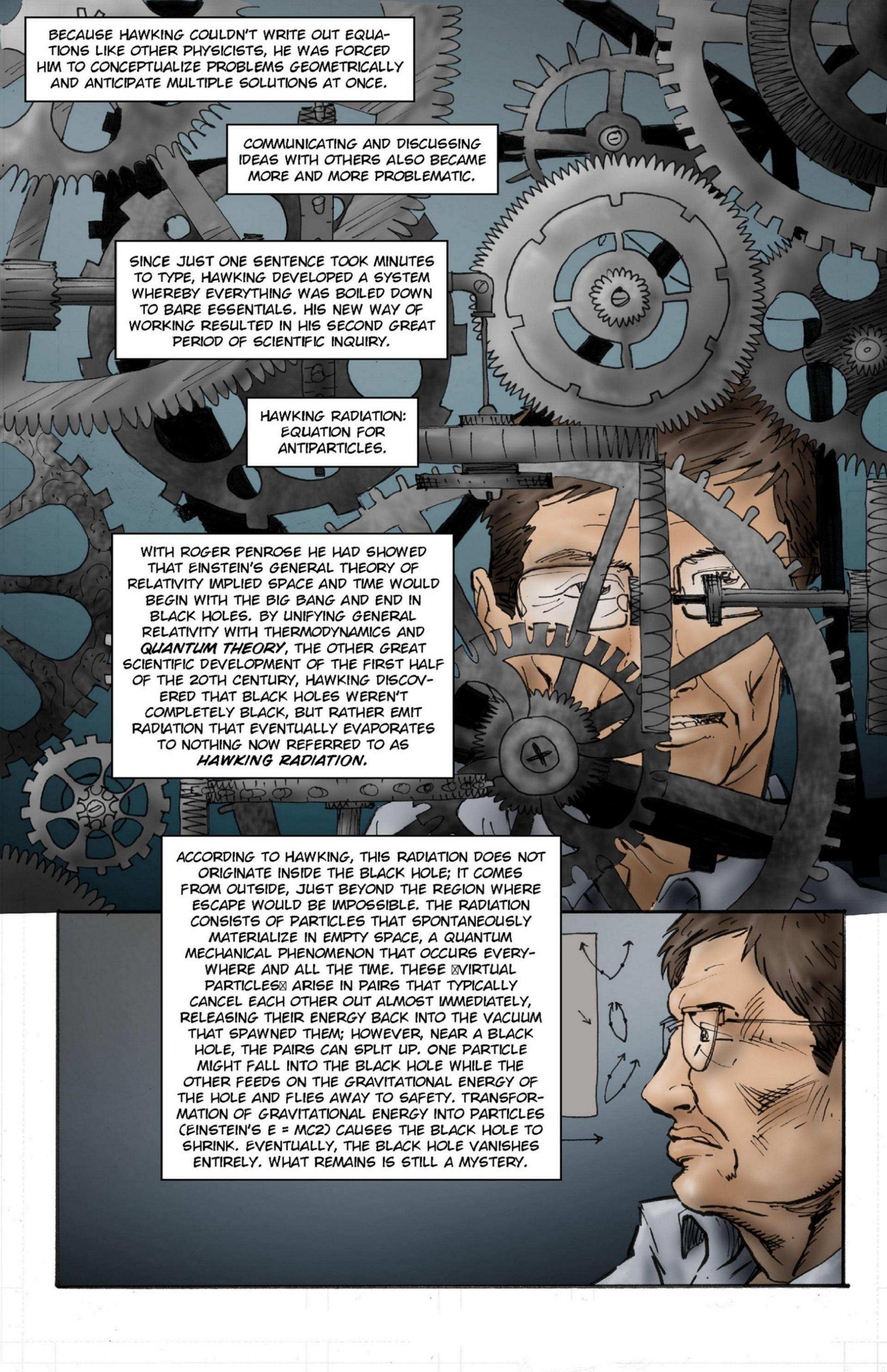
In case you're wondering, my present computer runs on batteries under the wheel chair. Like the Terminator, it also has an axillary internal battery. I run a program called Equalizer, which I know sounds menacing but really isn't unless you get on my bad side.



I used to manipulate a cursor moving across the screen with a switch in my hand; however, in 2005, I lost the use of my fingers. Nowadays, I use my cheek muscle to signal an electronic sensor in my eyeglasses to interface and transmit instructions to the computer. I can select words that are printed on the lower part of the screen. When I have built up a sentence, I can send it to a speech synthesizer. I can write equations in words, and the program translates them into symbols, then prints them out.

I also have a universally programmable infrared remote control attached to my computer system. I can operate many of the electronic items in my home such as televisions, video recorders and music players. A radio control device enables me to open doors and operate lights throughout my home and office where I can get around virtually unassisted.

Simple, right?



BECAUSE HAWKING COULDN'T WRITE OUT EQUATIONS LIKE OTHER PHYSICISTS, HE WAS FORCED HIM TO CONCEPTUALIZE PROBLEMS GEOMETRICALLY AND ANTICIPATE MULTIPLE SOLUTIONS AT ONCE.

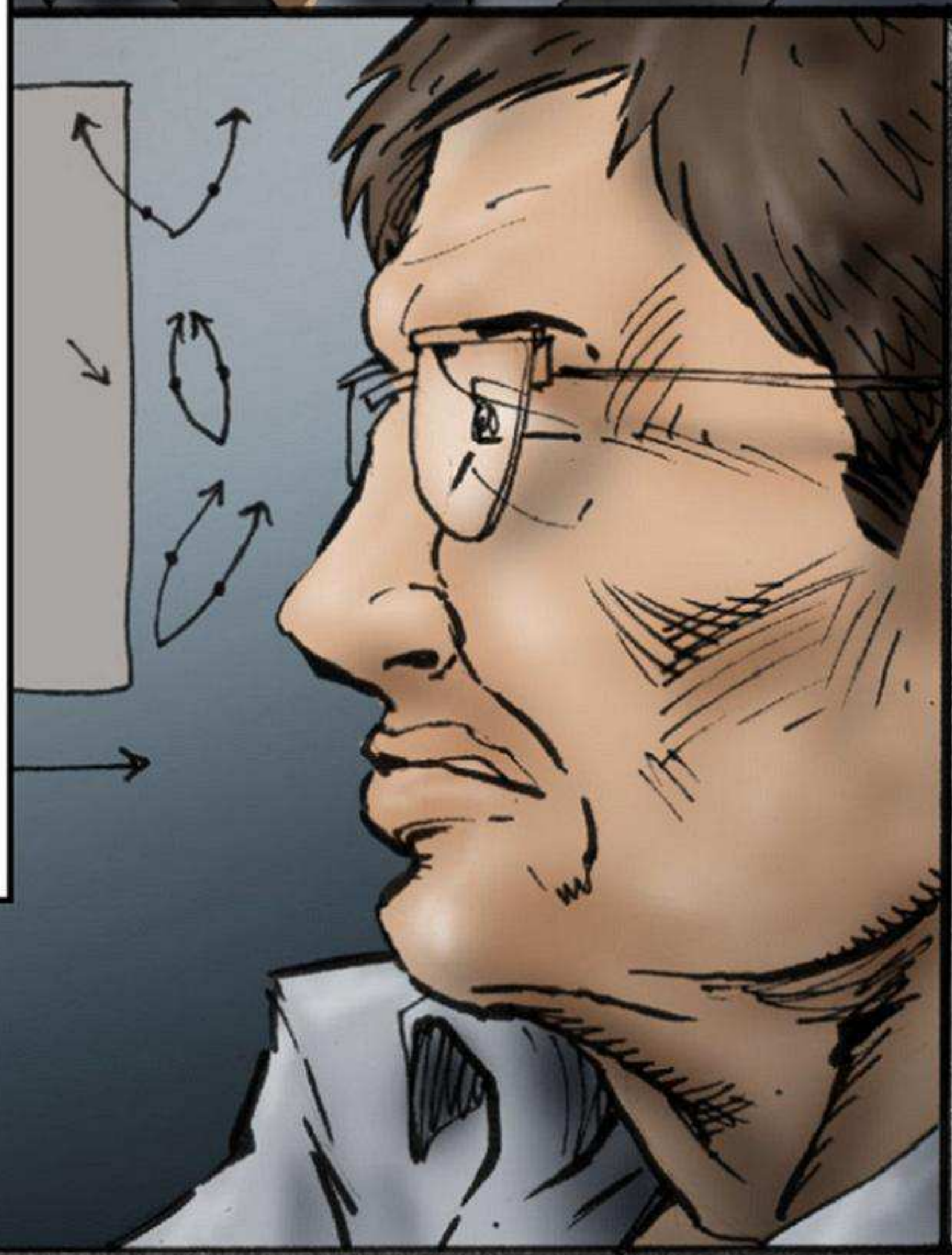
COMMUNICATING AND DISCUSSING IDEAS WITH OTHERS ALSO BECAME MORE AND MORE PROBLEMATIC.

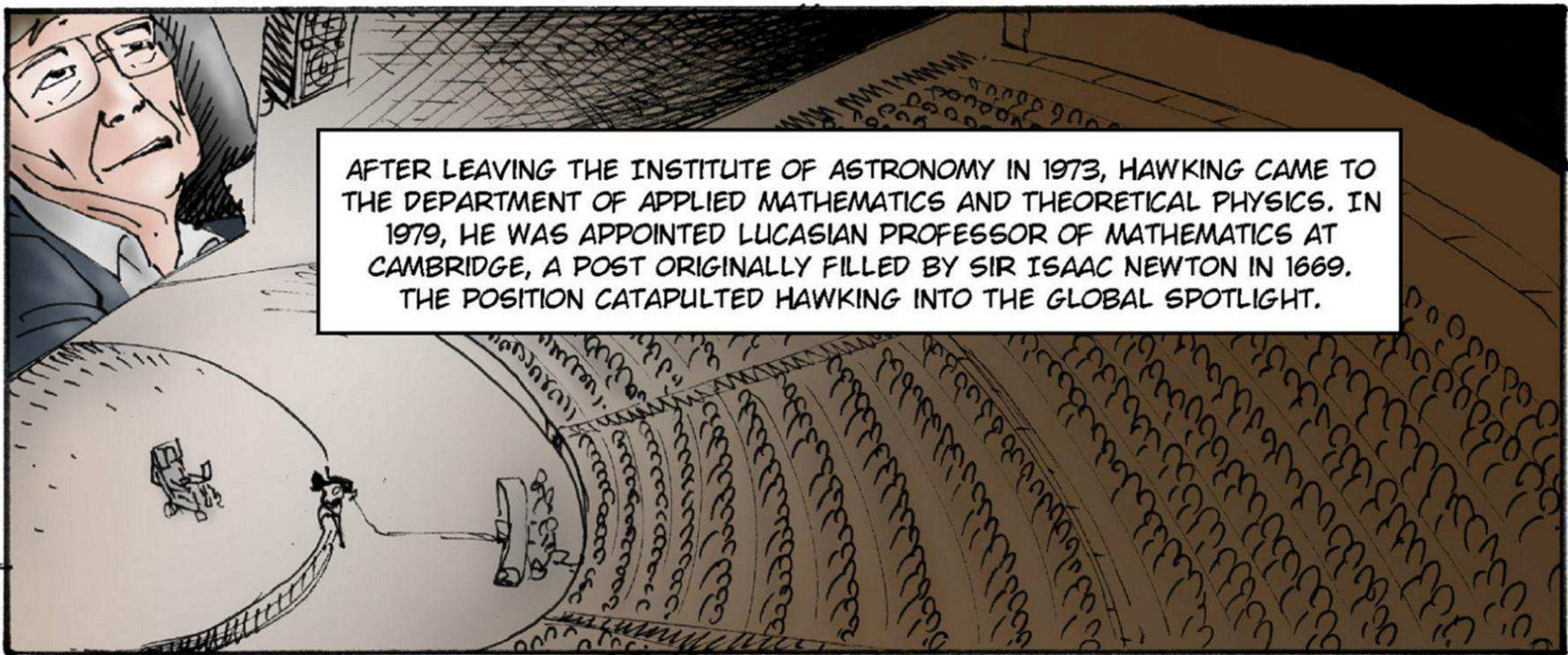
SINCE JUST ONE SENTENCE TOOK MINUTES TO TYPE, HAWKING DEVELOPED A SYSTEM WHEREBY EVERYTHING WAS BOILED DOWN TO BARE ESSENTIALS. HIS NEW WAY OF WORKING RESULTED IN HIS SECOND GREAT PERIOD OF SCIENTIFIC INQUIRY.

HAWKING RADIATION:
EQUATION FOR
ANTIPARTICLES.

WITH ROGER PENROSE HE HAD SHOWED THAT EINSTEIN'S GENERAL THEORY OF RELATIVITY IMPLIED SPACE AND TIME WOULD BEGIN WITH THE BIG BANG AND END IN BLACK HOLES. BY UNIFYING GENERAL RELATIVITY WITH THERMODYNAMICS AND *QUANTUM THEORY*, THE OTHER GREAT SCIENTIFIC DEVELOPMENT OF THE FIRST HALF OF THE 20TH CENTURY, HAWKING DISCOVERED THAT BLACK HOLES WEREN'T COMPLETELY BLACK, BUT RATHER EMIT RADIATION THAT EVENTUALLY EVAPORATES TO NOTHING NOW REFERRED TO AS *HAWKING RADIATION*.

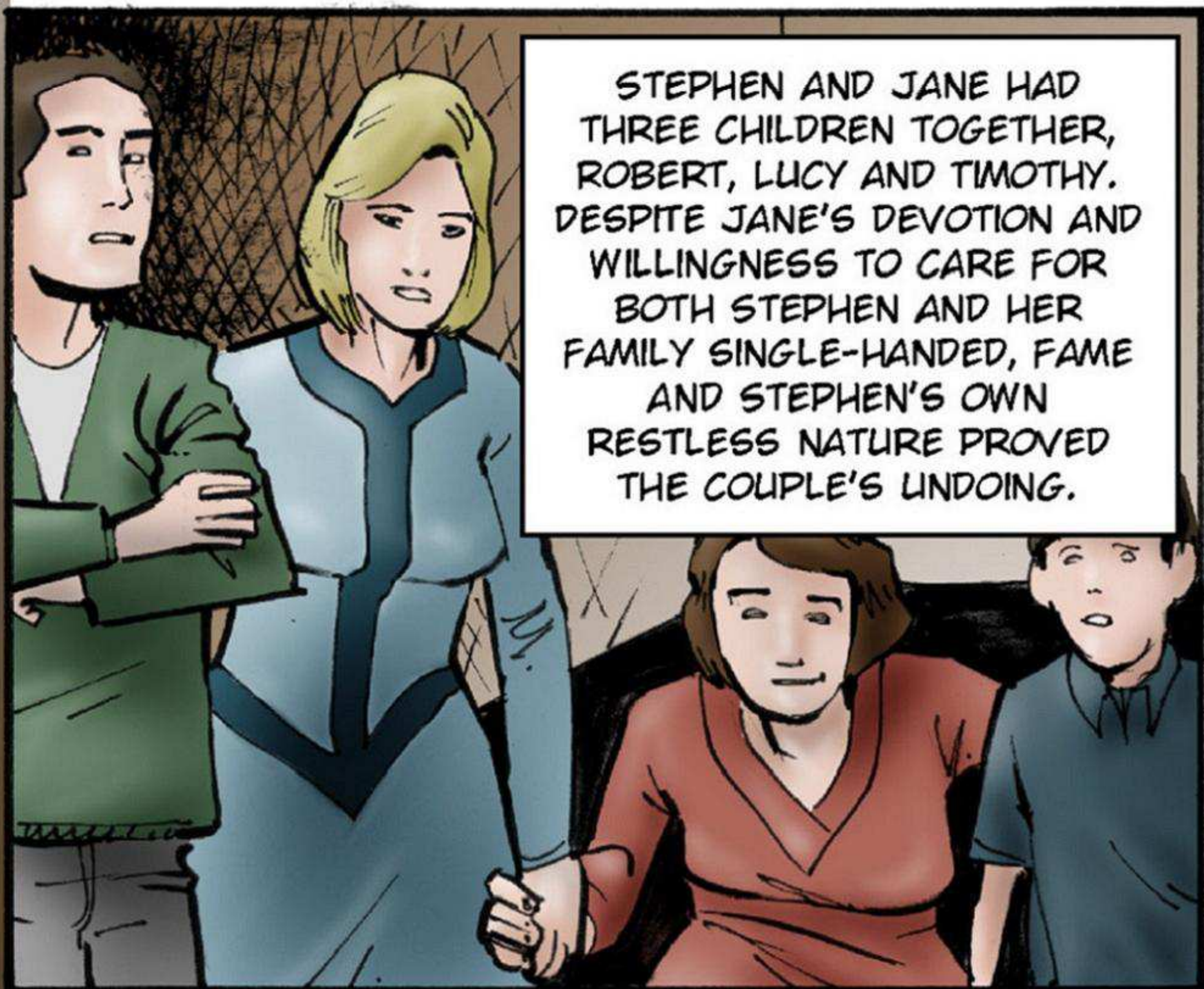
ACCORDING TO HAWKING, THIS RADIATION DOES NOT ORIGINATE INSIDE THE BLACK HOLE; IT COMES FROM OUTSIDE, JUST BEYOND THE REGION WHERE ESCAPE WOULD BE IMPOSSIBLE. THE RADIATION CONSISTS OF PARTICLES THAT SPONTANEOUSLY MATERIALIZE IN EMPTY SPACE, A QUANTUM MECHANICAL PHENOMENON THAT OCCURS EVERYWHERE AND ALL THE TIME. THESE "VIRTUAL PARTICLES" ARISE IN PAIRS THAT TYPICALLY CANCEL EACH OTHER OUT ALMOST IMMEDIATELY, RELEASING THEIR ENERGY BACK INTO THE VACUUM THAT SPAWNED THEM; HOWEVER, NEAR A BLACK HOLE, THE PAIRS CAN SPLIT UP. ONE PARTICLE MIGHT FALL INTO THE BLACK HOLE WHILE THE OTHER FEEDS ON THE GRAVITATIONAL ENERGY OF THE HOLE AND FLIES AWAY TO SAFETY. TRANSFORMATION OF GRAVITATIONAL ENERGY INTO PARTICLES (EINSTEIN'S $E = MC^2$) CAUSES THE BLACK HOLE TO SHRINK. EVENTUALLY, THE BLACK HOLE VANISHES ENTIRELY. WHAT REMAINS IS STILL A MYSTERY.





AFTER LEAVING THE INSTITUTE OF ASTRONOMY IN 1973, HAWKING CAME TO THE DEPARTMENT OF APPLIED MATHEMATICS AND THEORETICAL PHYSICS. IN 1979, HE WAS APPOINTED LUCASIAN PROFESSOR OF MATHEMATICS AT CAMBRIDGE, A POST ORIGINALLY FILLED BY SIR ISAAC NEWTON IN 1669. THE POSITION CATAPULTED HAWKING INTO THE GLOBAL SPOTLIGHT.

SOON AFTER, IN 1988 HAWKING PUBLISHED THE PROVOCATIVE BUT OBSCURE, *A BRIEF HISTORY OF TIME*. THE BOOK WAS A RUNAWAY BESTSELLER, SELLING 25 MILLION COPIES WORLDWIDE DESPITE THE FACT THAT FEW READ IT COVER-TO-COVER AND EVEN FEWER COULD UNDERSTAND IT.

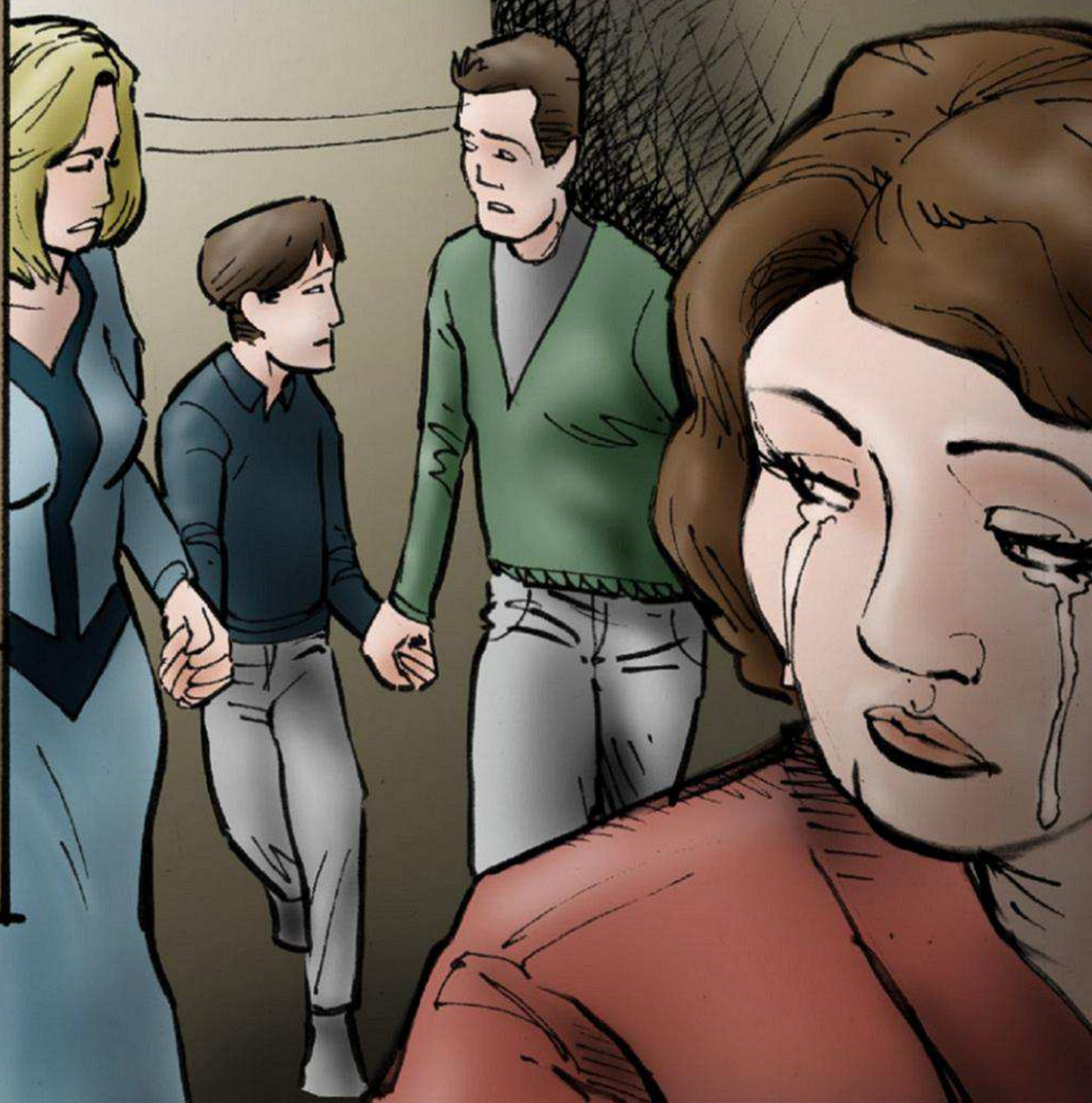


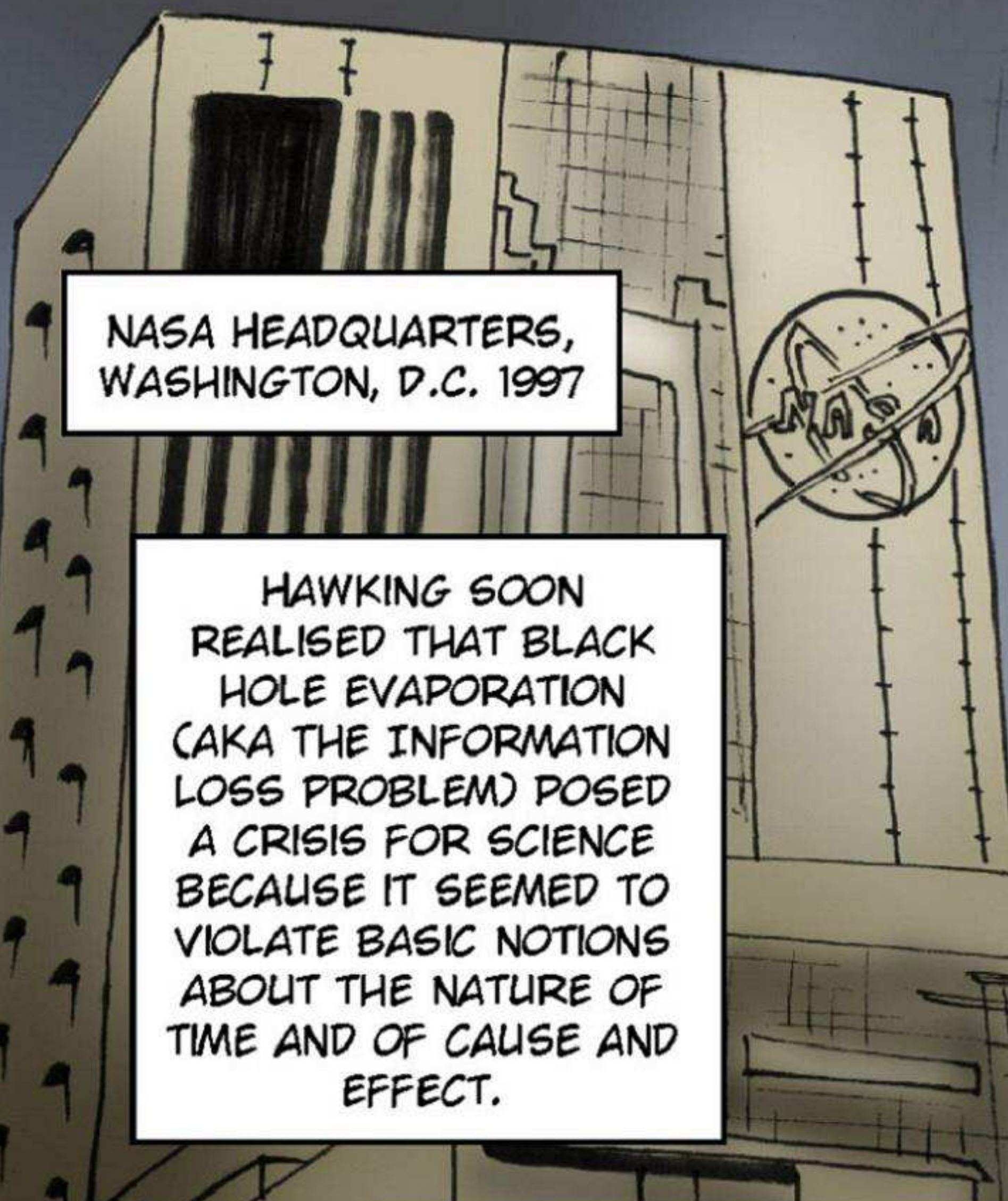
STEPHEN AND JANE HAD THREE CHILDREN TOGETHER, ROBERT, LUCY AND TIMOTHY. DESPITE JANE'S DEVOTION AND WILLINGNESS TO CARE FOR BOTH STEPHEN AND HER FAMILY SINGLE-HANDED, FAME AND STEPHEN'S OWN RESTLESS NATURE PROVED THE COUPLE'S UNDOING.



STEPHEN AND JANE WOULD DIVORCE IN 1991.

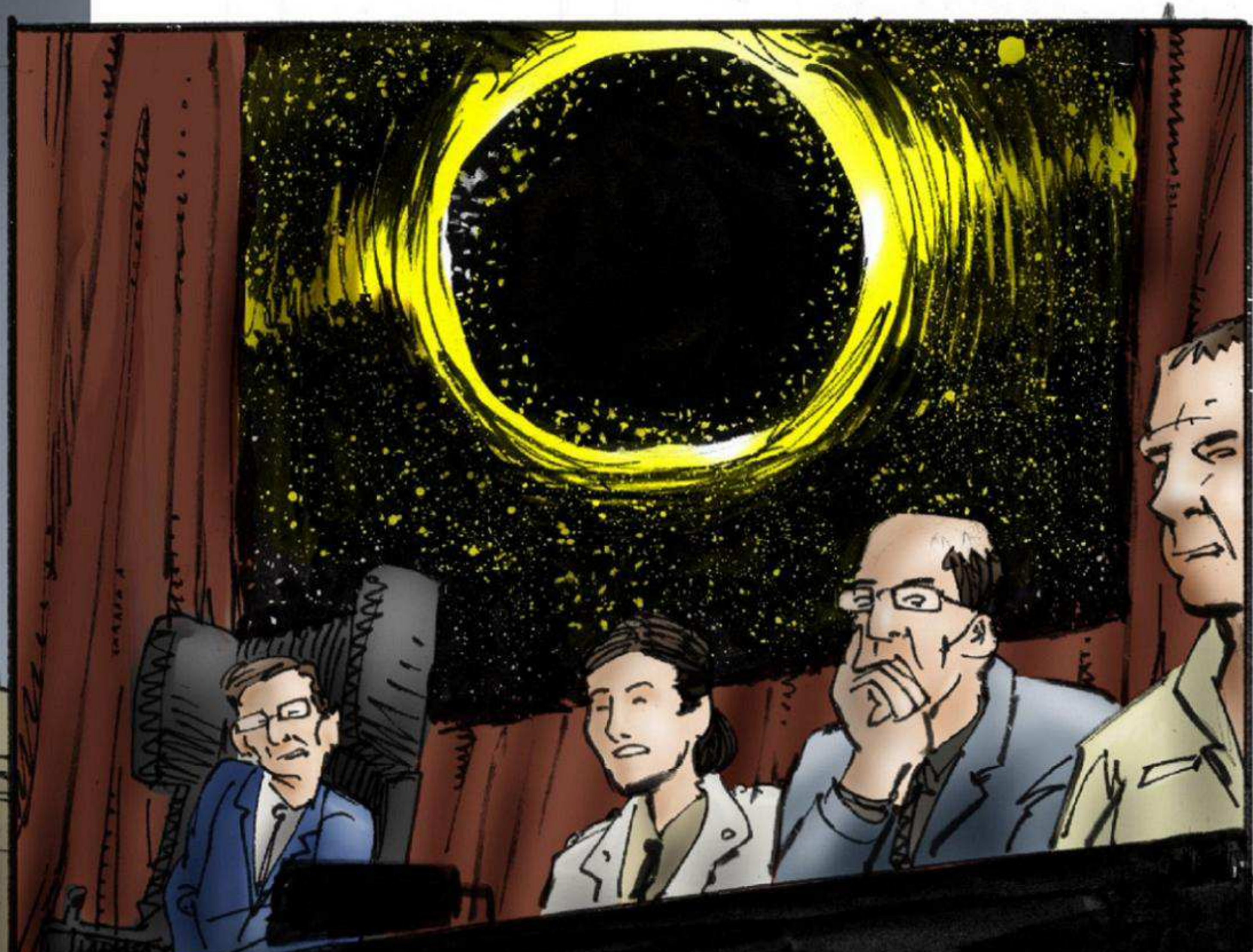
HAWKING WOULD MARRY HIS NURSE ELAINE MASON IN 1995. THEY WOULD DIVORCE IN 2006. HE WOULD RECONCILE WITH HIS FAMILY THE FOLLOWING YEAR.






NASA HEADQUARTERS,
WASHINGTON, D.C. 1997

HAWKING SOON
REALISED THAT BLACK
HOLE EVAPORATION
(AKA THE INFORMATION
LOSS PROBLEM) POSED
A CRISIS FOR SCIENCE
BECAUSE IT SEEMED TO
VIOLATE BASIC NOTIONS
ABOUT THE NATURE OF
TIME AND OF CAUSE AND
EFFECT.




THERE SEEMED TO BE ONLY TWO POSSIBLE EXPLANA-
TIONS FOR THE MYSTERY. EITHER HAWKING WAS WRONG
ABOUT BLACK HOLES' DESTROYING ALL TRACES OF THEIR
PAST, OR SOMETHING WAS TERRIBLY WRONG WITH
QUANTUM MECHANICS, WHOSE EQUATIONS REQUIRE THAT
INFORMATION CAN NEVER BE LOST. FOR YEARS HAWKING
THOUGHT THAT QUANTUM MECHANICS—THE FOUNDATION
OF MODERN PHYSICS—WOULD HAVE TO CHANGE.



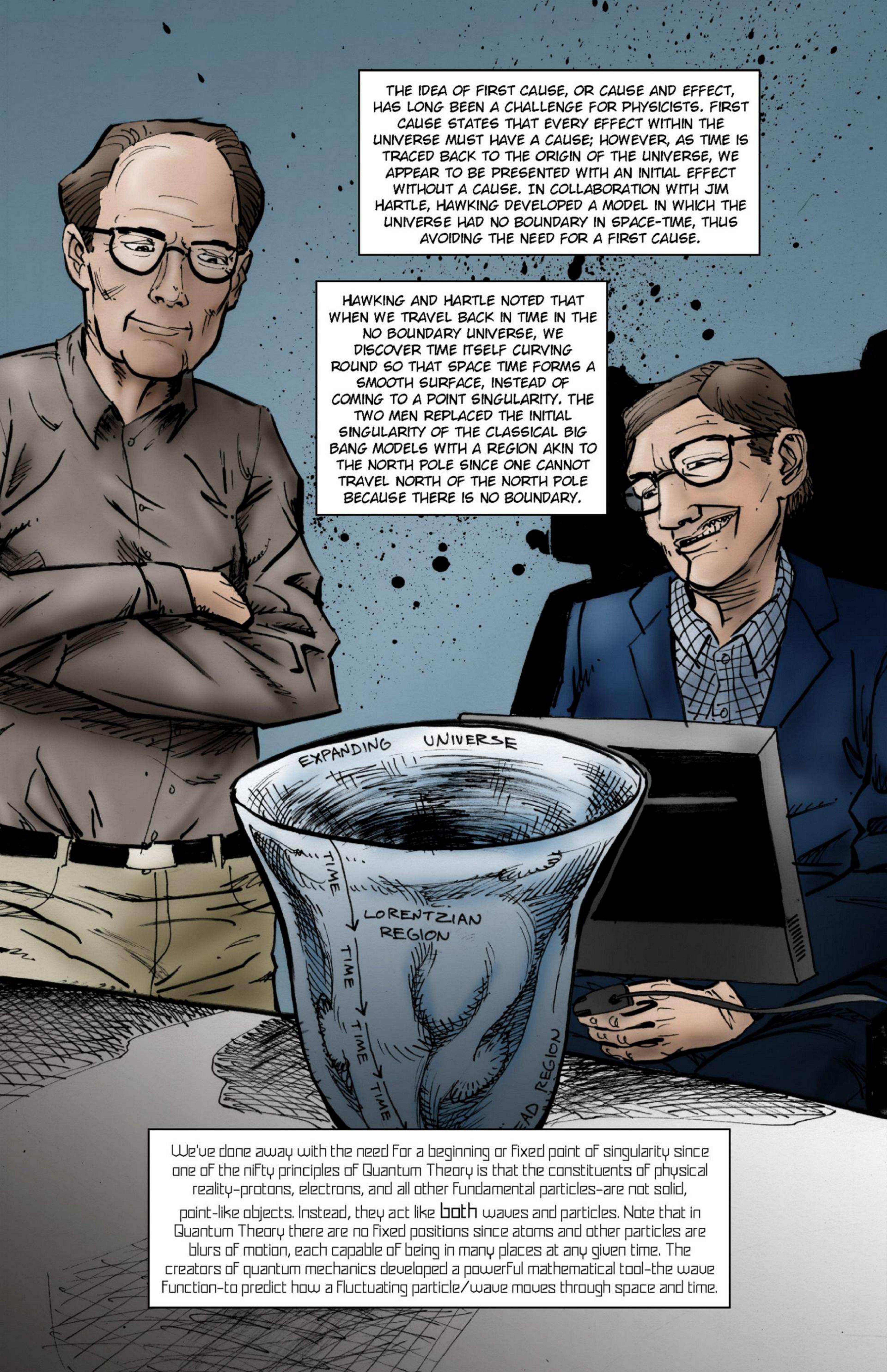
WITH ALL DUE RESPECT TO JOHN PRESKILL OF CALTECH,
I'M WILLING TO WAGER HIM A SET OF ENCYCLOPEDIAS
THAT THE INFORMATION IS LOST AND THAT BLACK HOLES
DESTROY ALL TRACE OF THEIR PAST, THUS QUANTUM
MECHANICS IS WRONG ON SOME LEVEL.

PRESKILL BET THAT QUANTUM THEORY WOULD BE VINDICATED.
IN JULY OF 2004, HAWKING HAD ARRIVED AT NEW CALCULA-
TIONS SHOWING THAT BLACK HOLE RADIATION COULD POTEN-
Tially CONTAIN TRACES OF ENCODED INFORMATION ABOUT THE
PAST. THAT SAME YEAR, HAWKING CONCEDED THE BET AND
GAVE PRESKILL AN ENCYCLOPEDIA OF BASEBALL STATISTICS;
HOWEVER, MANY PHYSICISTS CONTINUE TO DEBATE THE ISSUE.

A true event
horizon never
forms.




IN THE MEANTIME,
HAWKING TURNED
HIS ATTENTION TO
THE PROBLEM OF
FIRST CAUSE...




THE IDEA OF FIRST CAUSE, OR CAUSE AND EFFECT, HAS LONG BEEN A CHALLENGE FOR PHYSICISTS. FIRST CAUSE STATES THAT EVERY EFFECT WITHIN THE UNIVERSE MUST HAVE A CAUSE; HOWEVER, AS TIME IS TRACED BACK TO THE ORIGIN OF THE UNIVERSE, WE APPEAR TO BE PRESENTED WITH AN INITIAL EFFECT WITHOUT A CAUSE. IN COLLABORATION WITH JIM HARTLE, HAWKING DEVELOPED A MODEL IN WHICH THE UNIVERSE HAD NO BOUNDARY IN SPACE-TIME, THUS AVOIDING THE NEED FOR A FIRST CAUSE.

HAWKING AND HARTLE NOTED THAT WHEN WE TRAVEL BACK IN TIME IN THE NO BOUNDARY UNIVERSE, WE DISCOVER TIME ITSELF CURVING ROUND SO THAT SPACE TIME FORMS A SMOOTH SURFACE, INSTEAD OF COMING TO A POINT SINGULARITY. THE TWO MEN REPLACED THE INITIAL SINGULARITY OF THE CLASSICAL BIG BANG MODELS WITH A REGION AKIN TO THE NORTH POLE SINCE ONE CANNOT TRAVEL NORTH OF THE NORTH POLE BECAUSE THERE IS NO BOUNDARY.

We've done away with the need for a beginning or fixed point of singularity since one of the nifty principles of Quantum Theory is that the constituents of physical reality—protons, electrons, and all other fundamental particles—are not solid, point-like objects. Instead, they act like **both** waves and particles. Note that in Quantum Theory there are no fixed positions since atoms and other particles are blurs of motion, each capable of being in many places at any given time. The creators of quantum mechanics developed a powerful mathematical tool—the wave function—to predict how a fluctuating particle/wave moves through space and time.




IN 2006, A THIRD PHASE OF HAWKING'S WORK HAD BEGUN WHEN HE AND THOMAS HERTOG PROPOSED A NEW THEORY THEY CALLED **"TOP-DOWN COSMOLOGY"** WHICH STATED THAT THE UNIVERSE HAD NO UNIQUE BEGINNING, BUT RATHER EMERGED OUT OF MANY POSSIBLE BEGINNINGS, THE VAST MAJORITY WHICH WITHERED AWAY LEAVING LITTLE TRACE IN OUR PRESENT UNIVERSE. HAWKING AND HERTOG POSTULATED THAT IT WAS INAPPROPRIATE FOR PHYSICISTS TO ATTEMPT TO FORMULATE A THEORY THAT PREDICTS THE UNIVERSE'S CURRENT CONFIGURATION FROM ANY ONE PARTICULAR INITIAL STATE. THEY CALLED THEIR THEORY TOP-DOWN COSMOLOGY, BECAUSE INSTEAD OF LOOKING FOR SOME FUNDAMENTAL SET OF INITIAL PHYSICAL LAWS UNDER WHICH OUR UNIVERSE UNFOLDED, IT STARTS **AT THE TOP** WITH WHAT WE HAVE TODAY, AND WORKS BACKWARDS TO SEE WHAT THE POSSIBILITIES MIGHT HAVE BEEN. IN OTHER WORDS, THE PRESENT CHOOSES THE PAST FROM AMONG MANY POSSIBLE HISTORIES.



THE THEORY SUGGESTS A POSSIBLE RESOLUTION OF THE FINE-TUNING QUESTION: IT IS INEVITABLE THAT WE FIND OUR UNIVERSE'S PRESENT PHYSICAL CONSTANTS, AS THE CURRENT UNIVERSE **"SELECTS"** ONLY THOSE PAST HISTORIES THAT LED TO THE PRESENT CONDITIONS. IN THIS WAY, TOP-DOWN COSMOLOGY PROVIDES AN ANTHROPIC EXPLANATION FOR WHY WE FIND OURSELVES IN A UNIVERSE THAT ALLOWS MATTER AND LIFE, WITHOUT INVOKING AN ENSEMBLE OF MULTIPLE UNIVERSES.


The universe we see is just one possible outcome among many, thus the past does not uniquely determine the present. In fact, the universe has many potential past histories and just as many potential beginnings. So it's possible that the present universe selects the past, hence **"top-down."**

Because there is a law such as gravity, the Universe can and will create itself from nothing. Spontaneous creation is the reason there is something rather than nothing, why the Universe exists, why we exist.



HAWKING'S MOST RECENT BOOK, **GRAND DESIGN**, REPRESENTS HIS MOST SPECULATIVE WORK TO-DATE AS HE ATTEMPTS TO EXPLAIN THE UNIVERSE BY EMBRACING A UNIFYING FRAMEWORK CALLED **M-THEORY** THAT CAN BRING TOGETHER QUANTUM MECHANICS WITH GENERAL RELATIVITY. HE POSTULATED THAT THE UNIVERSE HAS NO EDGE OR BOUNDARY IN IMAGINARY TIME, AND THUS, ITS ORIGIN WAS COMPLETELY DETERMINED BY A SET OF NEWLY DISCOVERED MULTI-DIMENSIONAL LAWS OF SCIENCE.

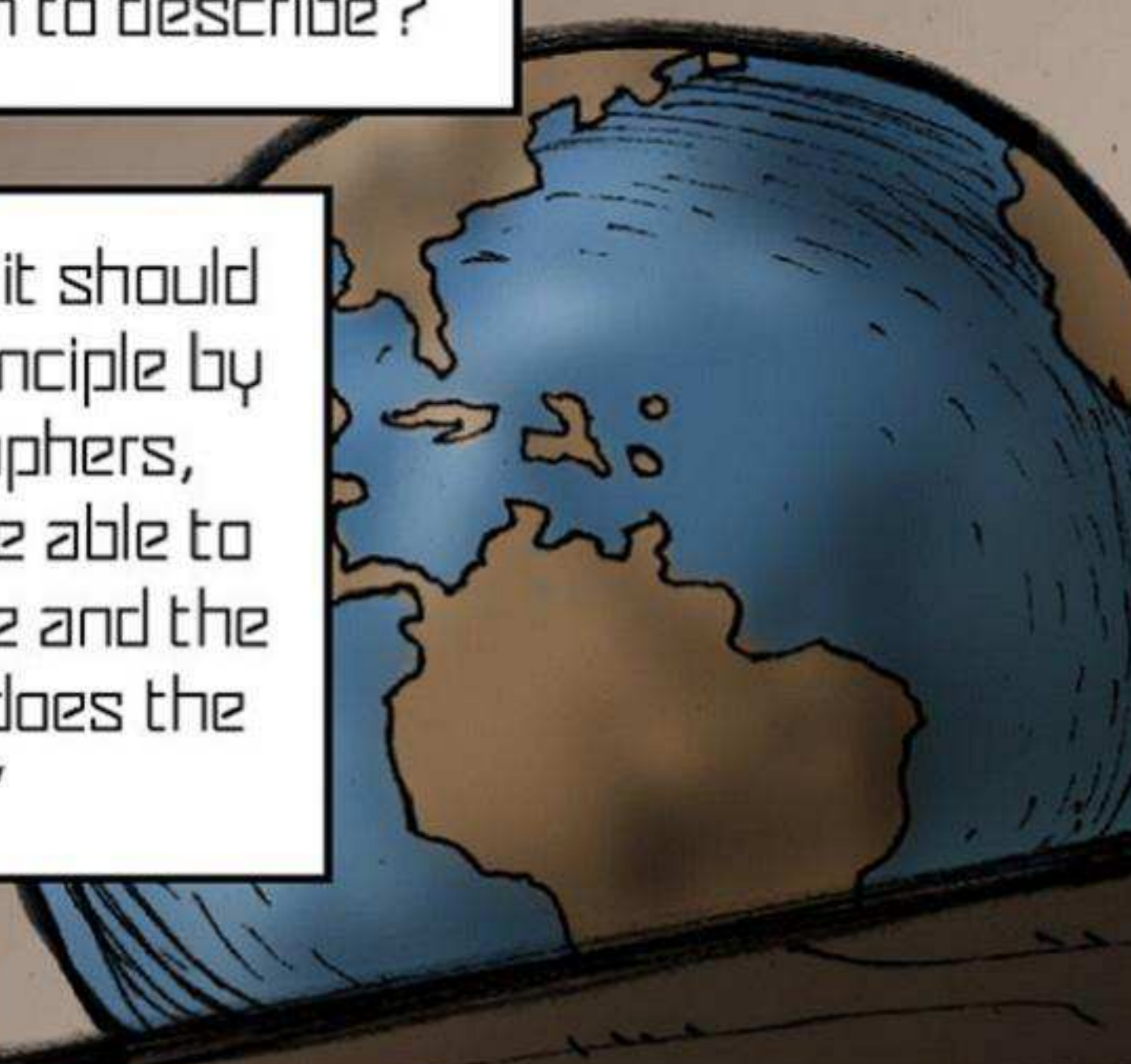
M-THEORY IMAGINES THE EXISTENCE OF 11 SPACE-TIME DIMENSIONS AND CONTAINS A PRINCIPAL CONCEPTUAL COMPONENT KNOWN AS **"STRING THEORY"** OR **"THE THEORY OF EVERYTHING."** EACH OF THESE DIMENSIONS ARE MADE UP OF INFINITELY SMALL BUILDING BLOCKS THAT MAY HAVE RISEN FROM NOTHING AND ALSO MAY OPERATE ON DIFFERING LAWS OF PHYSICS WITHIN EACH DIMENSION.

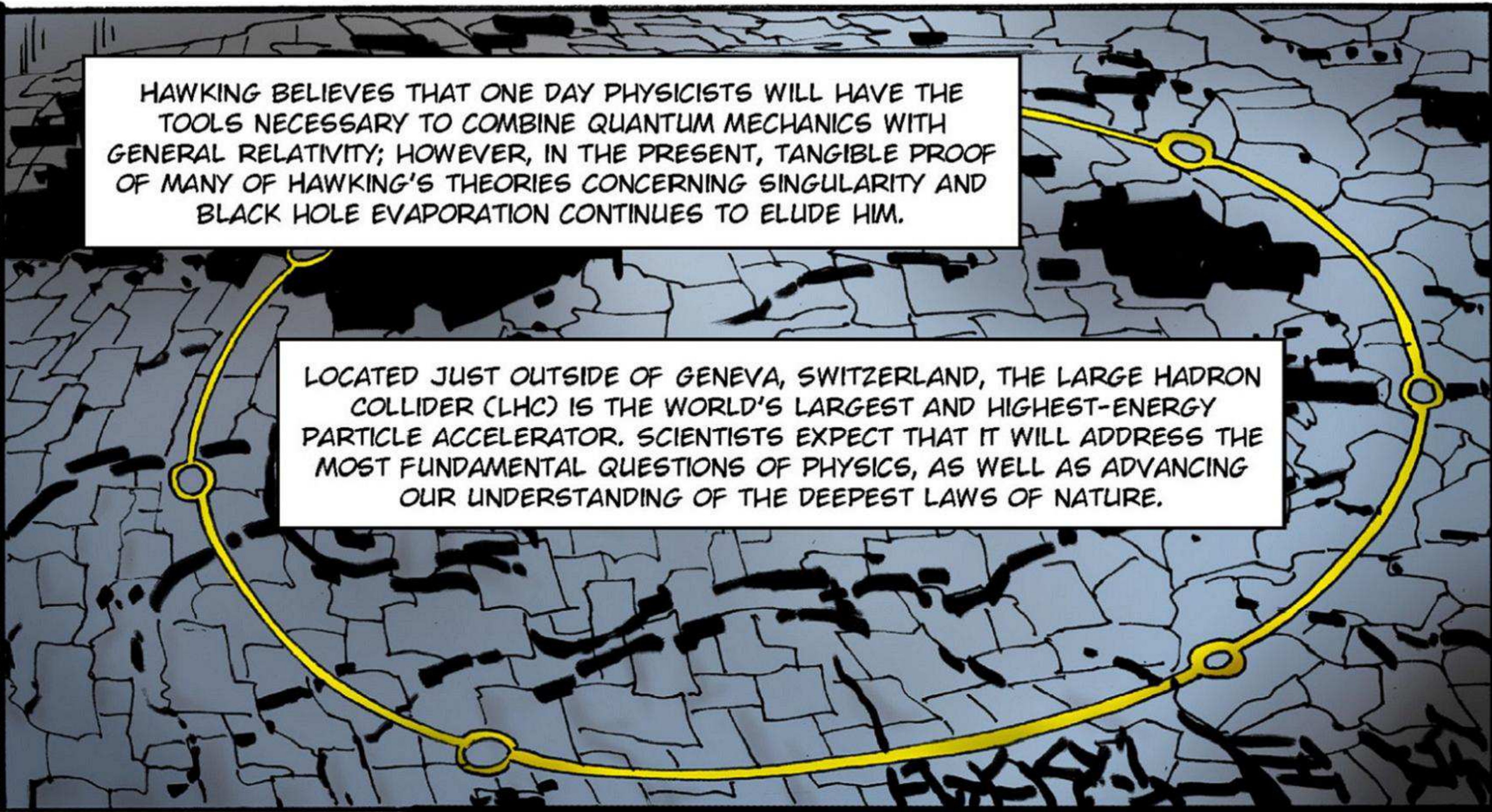


Our universe is a giant quantum phenomenon. Even if there is only one possible unified theory, it is just a set of rules and equations. What is it that breathes fire into the equations and makes a universe for them to describe?

If we do discover a complete theory, it should be in time understandable in broad principle by everyone. Then we shall all, philosophers, scientists, and just ordinary people be able to take part in the discussion of why we and the universe exist. For example, **"What does the 'm' stand for in M-Theory?"**

Alas, we may never know.





HAWKING BELIEVES THAT ONE DAY PHYSICISTS WILL HAVE THE TOOLS NECESSARY TO COMBINE QUANTUM MECHANICS WITH GENERAL RELATIVITY; HOWEVER, IN THE PRESENT, TANGIBLE PROOF OF MANY OF HAWKING'S THEORIES CONCERNING SINGULARITY AND BLACK HOLE EVAPORATION CONTINUES TO ELUDE HIM.

LOCATED JUST OUTSIDE OF GENEVA, SWITZERLAND, THE LARGE HADRON COLLIDER (LHC) IS THE WORLD'S LARGEST AND HIGHEST-ENERGY PARTICLE ACCELERATOR. SCIENTISTS EXPECT THAT IT WILL ADDRESS THE MOST FUNDAMENTAL QUESTIONS OF PHYSICS, AS WELL AS ADVANCING OUR UNDERSTANDING OF THE DEEPEST LAWS OF NATURE.



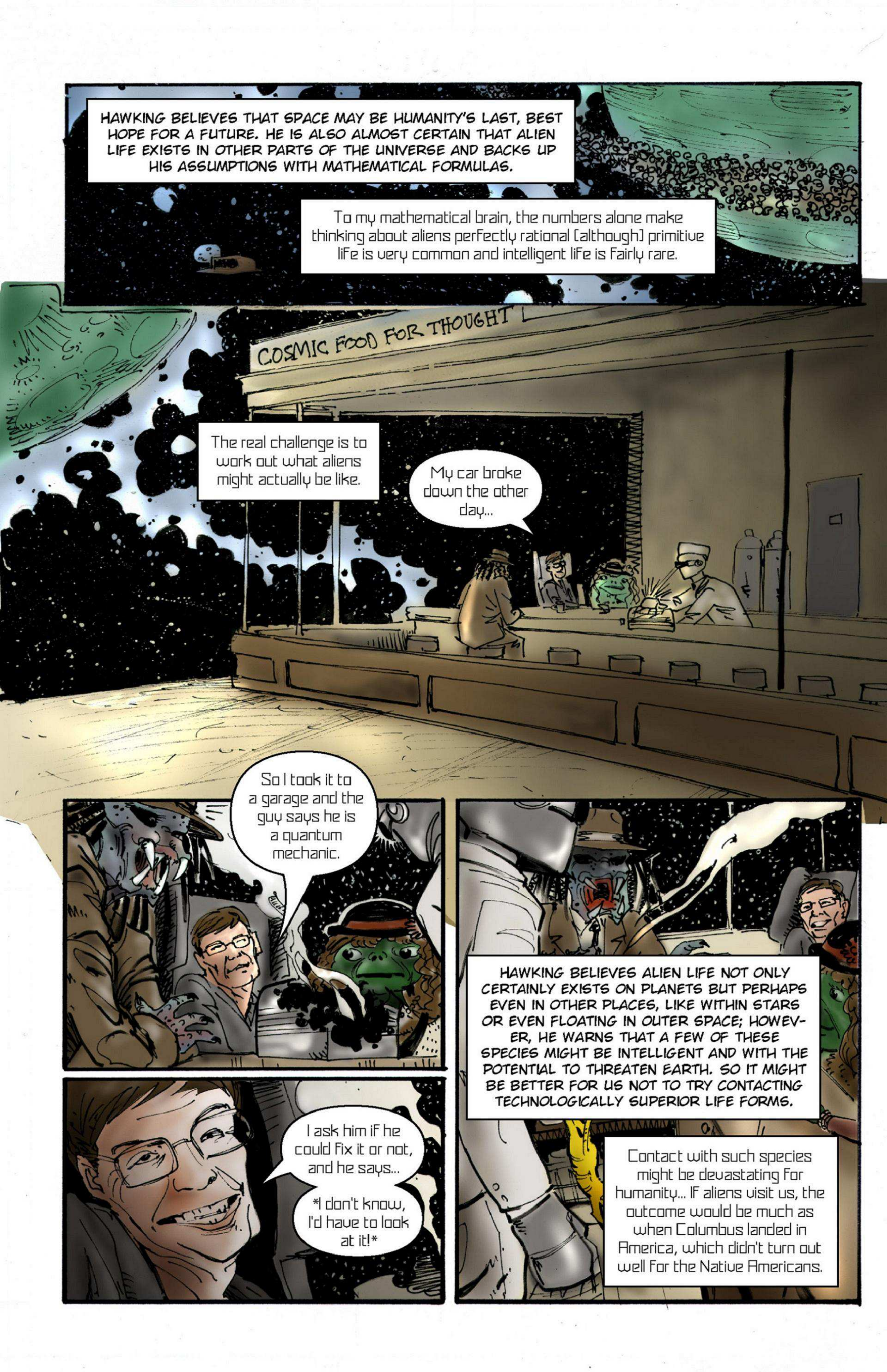
SOME HAVE FEARED THAT THE LHC MIGHT CREATE A MINIATURE BLACK HOLE CAPABLE OF DEVOURING OUR PLANET.

I put the probability and detection of a mini black hole forming at less than one percent...

Even so, such a black hole would evaporate almost as soon as it appeared... Just long enough to earn my Nobel Prize.



SO FAR, NO MINIATURE BLACK HOLE HAS BEEN CREATED OR DETECTED.



HAWKING BELIEVES THAT SPACE MAY BE HUMANITY'S LAST, BEST HOPE FOR A FUTURE. HE IS ALSO ALMOST CERTAIN THAT ALIEN LIFE EXISTS IN OTHER PARTS OF THE UNIVERSE AND BACKS UP HIS ASSUMPTIONS WITH MATHEMATICAL FORMULAS.

To my mathematical brain, the numbers alone make thinking about aliens perfectly rational [although] primitive life is very common and intelligent life is fairly rare.

The real challenge is to work out what aliens might actually be like.

My car broke down the other day...

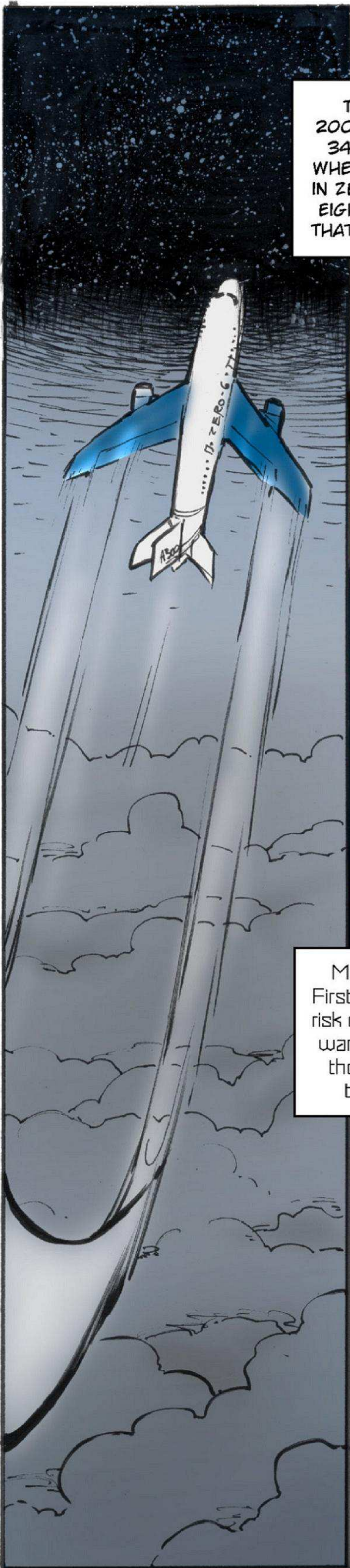
So I took it to a garage and the guy says he is a quantum mechanic.

HAWKING BELIEVES ALIEN LIFE NOT ONLY CERTAINLY EXISTS ON PLANETS BUT PERHAPS EVEN IN OTHER PLACES, LIKE WITHIN STARS OR EVEN FLOATING IN OUTER SPACE; HOWEVER, HE WARNS THAT A FEW OF THESE SPECIES MIGHT BE INTELLIGENT AND WITH THE POTENTIAL TO THREATEN EARTH. SO IT MIGHT BE BETTER FOR US NOT TO TRY CONTACTING TECHNOLOGICALLY SUPERIOR LIFE FORMS.


I ask him if he could fix it or not, and he says...

I don't know, I'd have to look at it!

Contact with such species might be devastating for humanity... If aliens visit us, the outcome would be much as when Columbus landed in America, which didn't turn out well for the Native Americans.



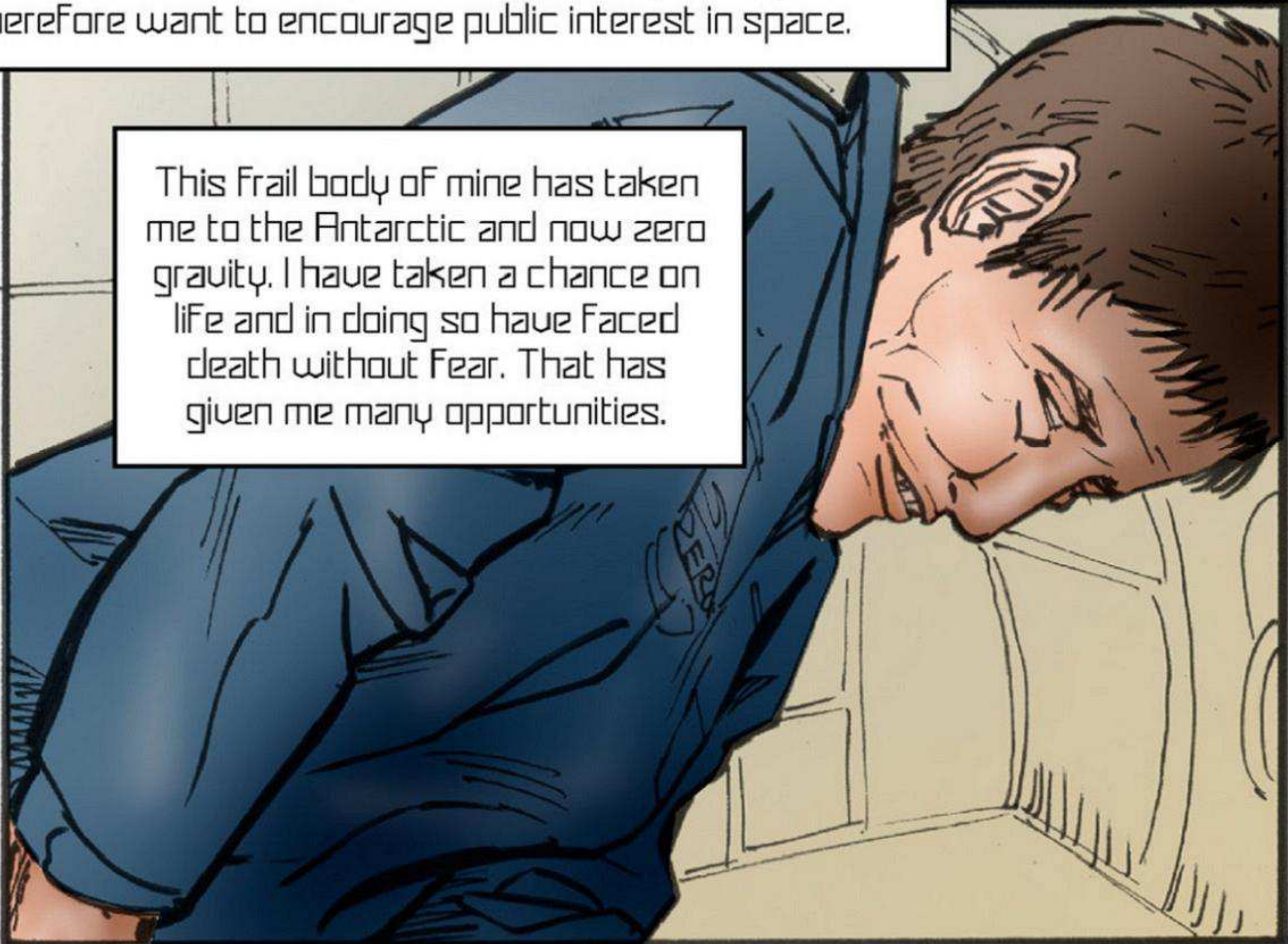
TO CELEBRATE HIS SIXTY-FIFTH BIRTHDAY IN APRIL, 2007, HAWKING TOOK A ZERO-GRAVITY FLIGHT ON A JET 34,000 FEET OVER THE ATLANTIC OCEAN OFF FLORIDA WHEREBY HE BECAME THE FIRST QUADRIPLÉGIC TO FLOAT IN ZERO-GRAVITY, WHILE EXPERIENCING WEIGHTLESSNESS EIGHT TIMES. THIS WAS THE FIRST TIME IN FORTY YEARS THAT HAWKING MOVED FREELY WITHOUT HIS WHEELCHAIR.



It is a waste of time to be angry about my disability. One has to get on with life and I haven't done badly. People won't have time for you if you are always angry or complaining.

Space, here I come!

Many people have asked me why I am taking this flight... First of all, I believe that life on Earth is at an ever-increasing risk of being wiped out by a disaster such as sudden nuclear war, a genetically engineered virus, or other dangers. I think the human race has no future if it doesn't go into space. I therefore want to encourage public interest in space.



This frail body of mine has taken me to the Antarctic and now zero gravity. I have taken a chance on life and in doing so have faced death without fear. That has given me many opportunities.

DESPITE HIS MOTOR NEURONE DISEASE, STEPHEN HAWKING CONTINUES TO COMBINE FAMILY LIFE (HE HAS THREE CHILDREN AND THREE GRANDCHILDREN), AND HIS RESEARCH INTO THEORETICAL PHYSICS TOGETHER WITH AN AMBITIOUS PROGRAM OF TRAVEL AND PUBLIC LECTURES. HAWKING'S SCIENTIFIC INVESTIGATIONS HAVE INCLUDED QUANTUM COSMOLOGY, THE NATURE OF SPACE AND TIME INCLUDING THE ARROW OF TIME, SPACETIME FOAM, STRING THEORY, SUPER GRAVITY, EUCLIDEAN QUANTUM GRAVITY, THE GRAVITATIONAL HAMILTONIAN, COSMIC INFLATION, HELIUM PRODUCTION IN ANISOTROPIC BIG BANG UNIVERSES, LARGE N COSMOLOGY, THE DENSITY MATRIX OF THE UNIVERSE, BABY UNIVERSES, TOPOLOGY AND STRUCTURE OF THE UNIVERSE, ANTI DE SITTER SPACE, YANG-MILLS INSTANTONS AND THE S MATRIX, QUANTUM ENTANGLEMENT AND ENTROPY, BRANS-DICKE AND HOYLE-NARLIKAR THEORIES OF GRAVITATION, GRAVITATIONAL RADIATION, AND WORMHOLES.

HIS SCIENTIFIC PUBLICATIONS INCLUDE THE LARGE SCALE STRUCTURE OF SPACETIME WITH G F R ELLIS, GENERAL RELATIVITY: AN EINSTEIN CENTENARY SURVEY WITH W ISRAEL, AND 300 YEARS OF GRAVITY WITH W ISRAEL. STEPHEN HAWKING HAS PUBLISHED SEVERAL POPULAR BOOKS INCLUDING HIS BEST SELLER A BRIEF HISTORY OF TIME, BLACK HOLES AND BABY UNIVERSES AND OTHER ESSAYS, THE UNIVERSE IN A NUTSHELL, AND MOST RECENTLY IN 2011, THE GRAND DESIGN WITH LEONARD MLODINOW.

HAWKING HAS BEEN THE SUBJECT AND FASCINATION OF POP-CULTURE. HE AND/OR HIS LIKENESS HAVE APPEARED ON THE SIMPSONS, STAR TREK, STARGATE ATLANTIC, DILBERT, FUTURAMA, AND AS AN INSPIRATION FOR THE CHARACTER OF DR. CHARLES XAVIER OF X-MEN.

HAWKING HOLDS TWELVE HONORARY DEGREES. HE IS THE RECIPIENT OF MANY AWARDS, MEDALS AND PRIZES INCLUDING THE MEDAL OF FREEDOM WHICH HE RECEIVED IN 2009.

YET, FOR ALL OF HAWKING'S CONTRIBUTIONS SOME UNCERTAINTY SHROUDS HIS LEGACY. UNLIKE THE WORK OF EINSTEIN, HAWKING'S THEORIES ON BLACK HOLES ARE UNLIKELY TO EVER BE OBSERVED. THEY REMAIN THEORIES.

We are just an advanced breed of monkeys on a minor planet of a very average star. But we can understand the Universe. That makes us something very special.

I hope you enjoyed our little journey. Remember: don't sweat the small stuff. Anything that doesn't matter has no mass.